FREQUENCY COUNTER FOR QRP WITH ONE 7 SEGMENTS DISPLAY

(1999)

Frequency counter for simple and small sized QRP equipment
We are used to the frequency counter with a row of 5 or 6 displays. And these counters are not what we want for our simple QRP equipment. They need more components and space and draw more current than our QRP rig!
But here is a perfect solution for this problem: The frequency counter with one 7 segments LED display! Well I can almost hear you think: THAT IS IMPOSSIBLE, but it is not! Indeed, one display is sufficient.
The interesting part of this article is more the idea of how to display the frequency with only one display than the hardware.

How does it work
Very simple! The counter has a MHz / kHz switch. If we have for example a frequency of 14062.3 kHz then the frequency is displayed as follows:

Example for: **14062.3** **kHz**

The switch is in the MHz position: (coarse tuning)

.....off measuring..... 1 *off* 4 *off* 0 *.....off measuring.....* 1 *off* 4 *off* 0 *.....off measuring.....*

"1" is displayed for 250 milliseconds.
" " display is off for 80 milliseconds.
"4" is displayed for 250 milliseconds.
" " display is off for 80 milliseconds.
"0" is displayed for 250 milliseconds.
And after a 500 ms (or 1 s) display off period during the next frequency measurement, the "140" is displayed again.

The switch is in the kHz position: (normal operating, fine tuning position)

.....off measuring..... 6 *off* 2 *off* 3 *.....off measuring.....* 6 *off* 2 *off* 3 *.....off measuring.....*

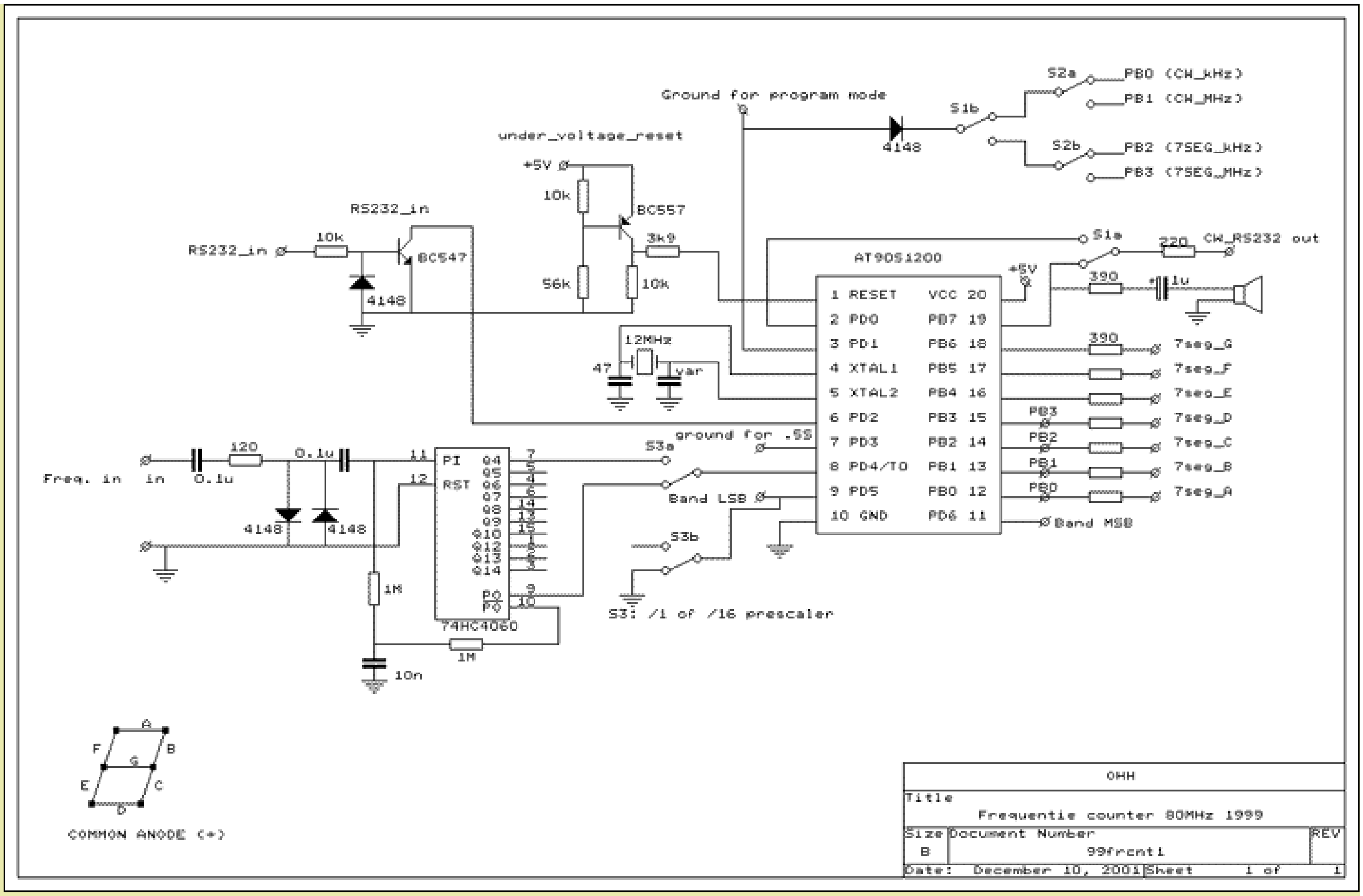
"6" is displayed for 250 milliseconds.
" " display is off for 80 milliseconds.

"2" is displayed for 250 milliseconds.
" " display is off for 80 milliseconds.
"3" is displayed for 250 milliseconds.
And after a 500 ms (or 1 s) display off period during the next frequency measurement, the "623" is displayed again.

The same counter in a QRP transceiver: Small size, low current and 100 Hz resolution!

Practical realisation of a one 7 segments display frequency counter

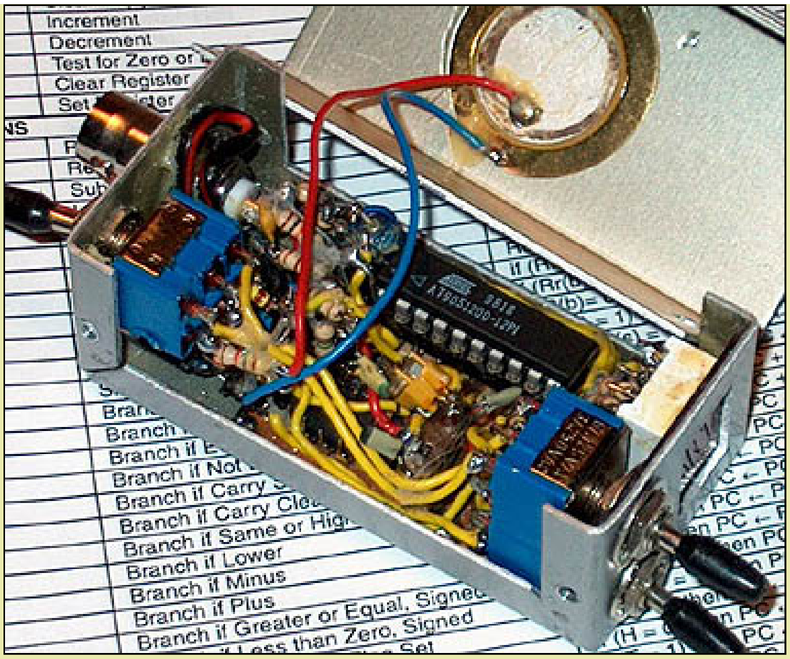
The design
The microcontroller AT90S1200 was selected for the job because I had a programming device for this RISC controller. This controller can count frequencies up to 6 MHz, so a 74HC4060 is used as /16 prescaler. During a 0.5 or 1 second period, the frequency is counted and then displayed via the 7 segments display in the way described here above.
There is also a 9600 baud RS232 connection for a PC. Via this connection, programming of frequency offsets and prescaler factor (power of 2) is possible.
The measured frequency is not only displayed, but is also sent to this RS232 port and can be displayed on your PC with a terminal program. It is also audible in CW via the internal beeper.



Circuit diagram

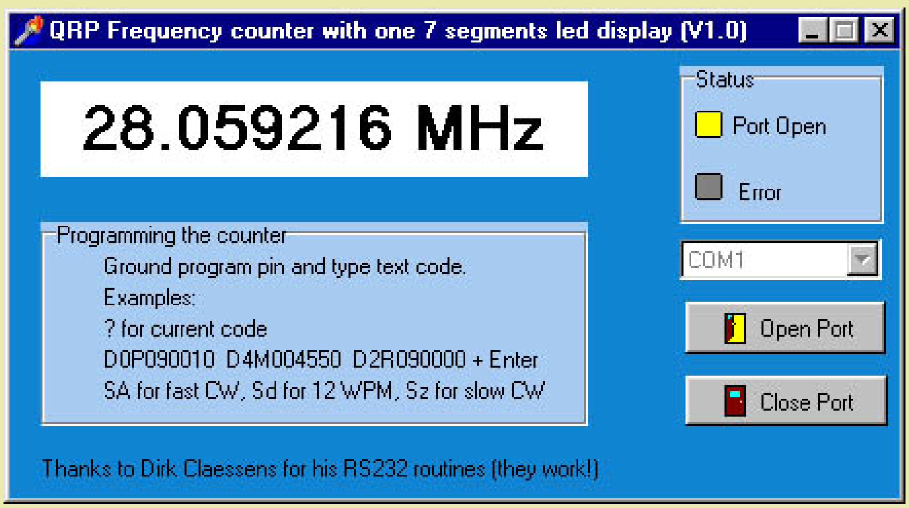
big diagram

Side view of the one display QRP frequency counter.



Inside

Reading the frequency and programming of the counter via the RS232 port.



The Windows program for reading the frequency and programming of the counter via the RS232 port.
Set the date of your PC to 2003 if you want to try this trial version.

Programming the frequency offset and CW speed
This is done via the RS232 port (9600 baud, 8 bits). Connect D1 to ground to enter the program mode.
Type a question mark '?' and then the current prescale / offset is displayed on the screen.
When programming the counter, type it exactly as given here (Watch the capitals!).

'D0Pmmkkkh' + ENTER is a positive offset (F=VFO+IF) and a prescaler of 1x (power of 2 is 0).
Example: 'D0P090010' + ENTER is a positive offset for a 9.001 MHz IF (BFO) frequency for 14 MHz and a 5 to 5.5 MHz VFO.

'D4Mmmkkkh' is a negative offset (F=VFO-IF) and a prescaler of /16 (power of 2 is 4).
Example: 'D4M004550' + ENTER is a negative offset for a 455 kHz IF frequency for AM broadcast with the local oscillator of approximately 955 kHz to 2055 kHz.

'D1Rmmkkkh' is a VFO lower than the IF (F=IF-VFO) and a prescaler of /2 (power of 2 is 1).
Example: 'D2R090000' + ENTER is a VFO lower than a 9 MHz IF, for example a 9 MHz IF in combination with a 5 to 5.5 MHz VFO for 3.5 to 4.0 MHz and a prescaler of /2.

'Sa' is the CW speed. This is directly related to the ASCII value of a.
Example: 'Sd' is an ASCII character with value 100 (d=ASCII 100) and is approximately 12 WPM.

Software.

Download the CNT7SEG.ZIP (7k) file containing the CNT7SEG.ASM code for the AT90S1200.

Download the CNT7SEGEXE.ZIP (216k) file containing the Windows RS232 communications program.

BACK TO INDEX PA2OHH

Harvesters

Energy Harvesting is the process by which energy from the surrounding environment is captured and stored. In recent years the term has been applied mainly to sensor networks, where autonomous sensor nodes employ this process to replenish their energy resources. When applied to our architecture, energy harvesting increases the robustness and availability of the system, making it energy-independent.

In our implementation, the harvesters charge a 12V motorcycle battery, which is the central energy storage of our system, and connects to an inverter to provide power to the 220V AC sockets and lights.

For our implementation, we planned on using four alternative energy sources:

- solar energy
- wind energy
- hydro energy
- wasted wireless energy

However, due to time constraints, we were not able to build very efficient harvesters for each of them. Yet, the Eneco system is completely autonomous - System Server, nodes, wireless router, actuators, they all draw power from the central battery.

By analyzing the data from the table below we can see that solar cells offer the best efficiency while, at the same time, are an environmentally-friendly power source. The purpose of the system is to combine solar energy with other available energy sources and, in case the energy sources are inefficient for a period of time, signal this to the user and take appropriate measures as to save as much energy as possible for the most important consumers.

Comparison of Energy Scavenging Sources

	Power Density ($\mu W/cm^3$) 1Year lifetime	Power Density ($\mu W/cm^3$) 10 Year lifetime	Source of information
Solar (Outdoors)	15,000 - direct sun 150 - cloudy day	15,000 - direct sun 150 - cloudy day	Commonly Available
Solar (Indoors)	6 - office desk	6 - office desk	Experiment
Vibrations	100 - 200	100 - 200	Experiment and Theory
Acoustic Noise	0.003 @ 75 Db 0.96 @ 100 Db	0.003 @ 75 Db 0.96 @ 100 Db	Theory
Daily Temp. Variation	10	10	Theory
Temperature Gradient	15 @ 10 °C gradient	15 @ 10 °C gradient	1997
Shoe Inserts	330	330	Starner 1996 Shenck & Paradiso 2001
Batteries (non-recharg. Lithium)	89	7	Commonly Available
Batteries (rechargeable Lithium)	13.7	0	Commonly Available
Gasoline (micro heat engine)	403	40.3	Mehra et. al. 2000
Fuel Cells (methanol)	560	56	Commonly Available

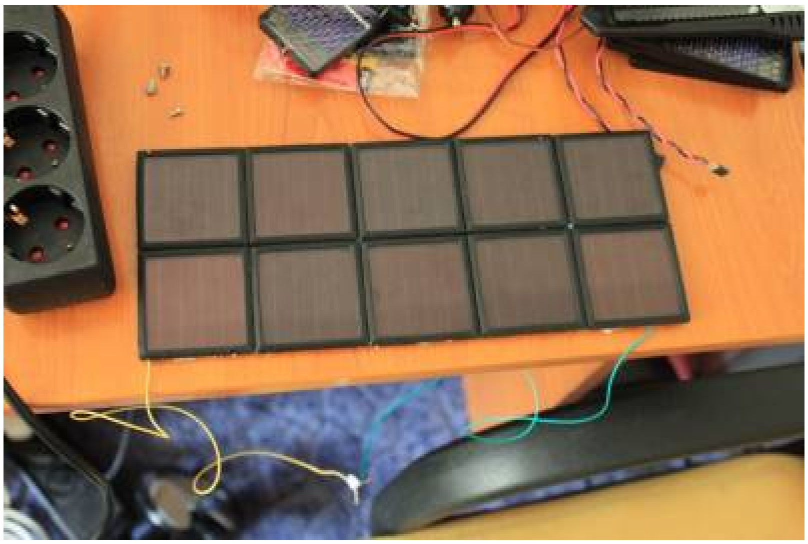
Harvesting Solar Energy

The most common energy scavenging technique is the use of photovoltaic cells to obtain power from ambient light, usually sunlight. For locations in which the availability of light to network nodes can be guaranteed to a sufficient degree, and for which mains and primary battery supply is impractical, this can be an excellent energy source.

The electrical power that can be extracted from a photovoltaic cell is proportional to the area of the cell and the intensity of the incident light. The terminal voltage of the cell resembles that of a semiconductor diode and is relatively insensitive to changes in light intensity, while the output current is directly proportional to light intensity.

By analyzing the data from the Table above we can see that solar cells o□ffer the best efficiency while at the same time being an environmentally-friendly power source.

We needed a cheap alternative to buying a big solar panel which would have been too expensive for our budget. While foraging around the city for parts, we found and bought a set of 10 cheap garden LED lamps. Their photovoltaic cells were ideal for our needs. Each of them outputs about 2.5V at 50mA, so, put together, they give enough power to charge the 12V battery. In order to simulate sunlight indoors, we also bought a 500W spotlight.

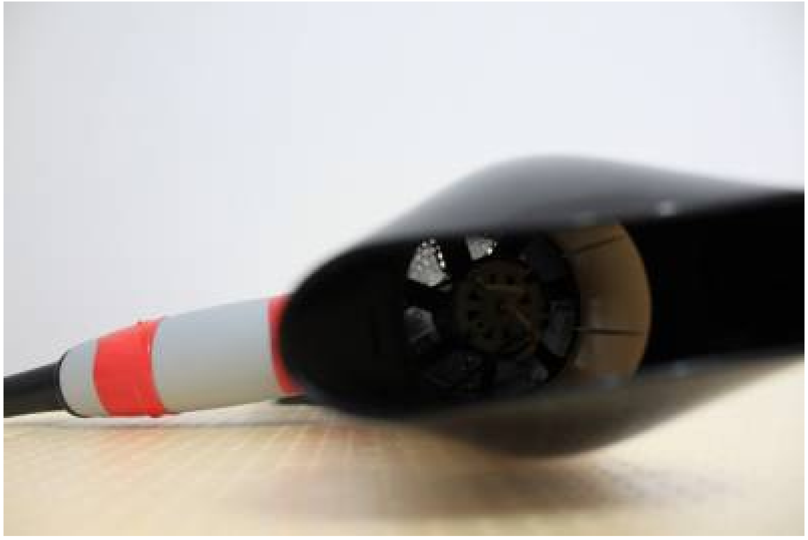


Harvesting Wind Energy

The efficiency of wind energy harvesting is also non-negligible, although it suffers from the drawback of not being always available. However, locations such as coastal areas and large open fields benefit from a constant breeze most of the year and, in the absence of wind power, solar energy can be reliably used as a complement.

For harvesting wind energy we are using a common fan, its DC motor used in reverse, as an electric dynamo. After rectifying the AC current generated by the motor, we managed to get a high enough voltage to charge the battery.

In order to simulate wind, we have also dismembered a hair drier.



Harvesting Wireless Microwave Energy

Typically, wireless sensors are designed to observe environments in a more flexible way than wired ones can, but sensor's power supply is the most confounding problem. In solving this problem, engineers dusted o a decades-old idea: radio-frequency energy recycling, be it from strategically placed transmitters or from the ambient energy emitted by cellphone towers and television stations. The concept was once dismissed as unfeasible because of the rapid dissipation of electromagnetic waves as they travel from their source . But even microwatts, if trickled into a battery or supercapacitor, can be enough to power some sensors. This is where the idea of a rectifying antenna, or rectenna comes in.

A rectenna is a special type of antenna that is used to directly convert microwave energy into DC electricity. A simple rectenna element consists of a dipole antenna with a Schottky diode placed across the dipole elements. The diode rectifies the AC current induced in the antenna by the microwaves, to produce DC power. Schottky diodes are used because they have the lowest voltage drop and highest speed and

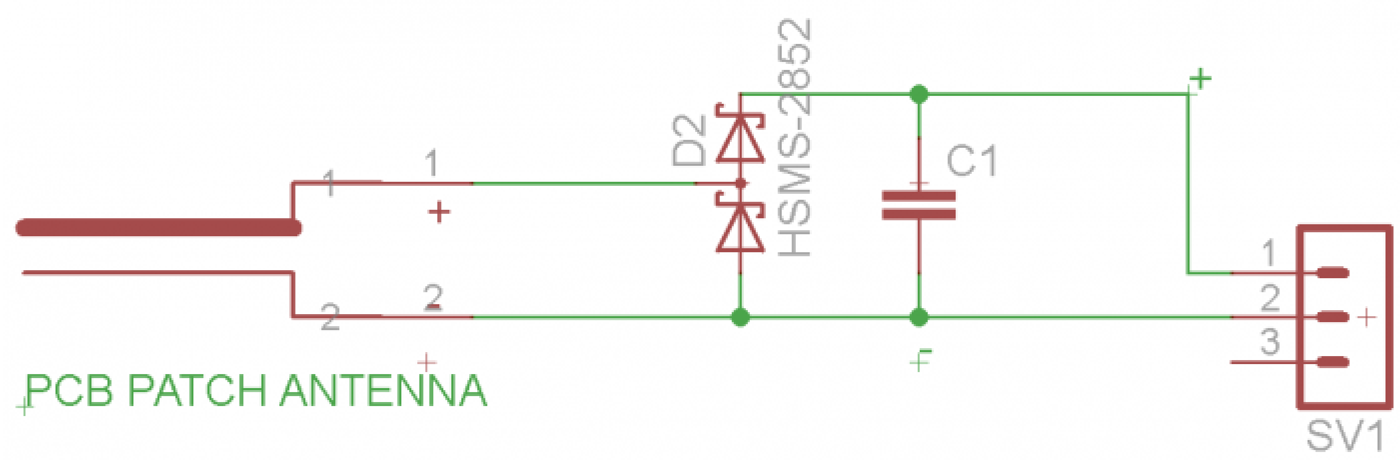
therefore waste the least amount of power due to conduction and switching. Large rectennas consist of an array of many such dipole elements.

We liked the idea of using rectennas for our design because, as opposed to the more well-known energy harvesting methods, it is a novel approach of getting power from the environment and it has remarkable efficiency (over 80% of captured microwave energy is converted to DC). Also, the fact that any modern living urban environment like a home or an office building is flooded with WiFi networks, GSM cellphones, repeaters and towers and even radio stations offers a strong incentive for implementing this type of energy harvesting.

There is only one drawback to this solution: one harvester is tuned to a very narrow frequency band and, if one wants to convert a wide band signal, multiple individual harvesters must be used, each tuned to a different frequency so that the whole spectrum is covered. However, all WiFi, Bluetooth and Zigbee networks operate in a narrow band around 2.4GHz and GSM networks around 900MHz. These are the types of networks most regularly found in a living environment, so designing harvesters for these two frequencies would yield close to optimal results.

Another good thing about rectennas is that they can be cheap to build and need very little additional components. The antenna part of the rectenna is a common patch, tuned for 2.4GHz and etched on a regular FR4 printed circuit board.

The rectifier (RF to DC conversion) circuits were designed using discrete Schottky barrier diodes. Two Agilent zero-bias diode pairs, HSMS-2852, were employed in a voltage doubler rectifier circuit. The HSMS-2852 diode was chosen as its performance is optimized for the chosen operating frequency band (2.4 GHz ISM band), and further, no external bias is required. The diodes appear in parallel to RF signals, but are in series for the DC circuit, as such the voltage output is doubled. To generate even higher voltages, additional voltage-doubler stages can be connected to the top of the aforementioned stage.



Arrays can be built by connecting in series like regular batteries large numbers of single-element harvesters. These have the advantage that they have a larger effective area and can harvest greater amounts of energy. Pictured bellow is such an array, near a single element harvester.

We tested the array around a regular wireless router and managed to harvest a few hundred microwatts of power from the ongoing wireless traffic. While this might not seem much, it was enough to light an LED diode. Given more time, we could have adapted this harvester to continuously trickle-charge a supercapacitor. That would have given us enough energy to power in bursts a wireless sensor node like the one we used for light intensity measurements.

harvesters.txt · Last modified: 2011/05/27 01:39 by acs

An Altoids Tin Low Pass Filter For Shortwave Transmitters

In my last post, the Michigan Mighty Mite was discussed; a very simple shortwave transmitter that puts out about a half a watt on several HF bands. The biggest problem with its simple design is that it outputs harmonics which should be filtered out.

I briefly discussed harmonics in my post on crystal oscillators. Crystal oscillators produce a square wave, which will produce odd harmonics. The Michigan Mighty Mite does produce a sine wave, and in theory a perfect sine wave won't produce any harmonics. In practice though, it's very difficult to tune this circuit to produce an absolutely perfect sine wave, and thus harmonics will be produced.

Luckily, it's relatively simple to filter out the harmonics you wish to eliminate with a low pass filter!

A low pass filter is essentially a LC circuit in a pi-network configuration. By choosing the correct inductor and capacitor values, you can configure the network to drop frequencies higher than a specified value.

These are the best two resources I've found on the web pertaining to low pass RF filters:

1. George Dobbs, G3RJV, A Short Guide to Harmonic Filters for QRP Transmitter Output. This is an awesome article, which lays out practical filter designs that work on a variety of shortwave bands. It also describes the best ferrite toroid values and wire gauges to use for creating inductors.

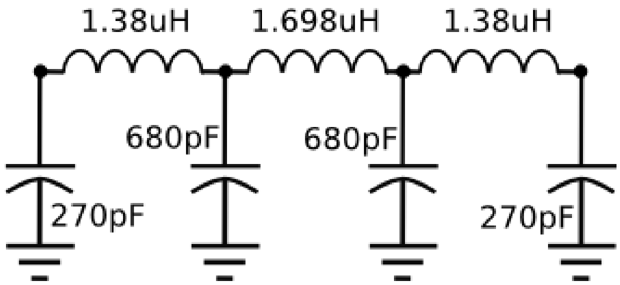
2. This website by WA4DSY automatically calculates the correct LC values for a filter by specifying the cutoff frequency, which will allow you to create a filter for practically any cutoff value. It also gives options for three different filter types: Butterworth, Chebyshev, and Bessel, as well as configurations for both high and low impedance filters, and a chart of the db drop off. Excellent!

Making a Low Pass RF Filter

Since I designed my Michigan Mighty Mite for the 40 meter band, I'm using G3RJV's design for 7.0 MHz filter. This design has a 3db cutoff frequency of 7.36 MHz and a 30db cutoff at 9.04 MHz. This should really dampen any spurious signals, since our first harmonic would be at around 14 MHz. This is a *7 pole* filter (one pole for each part -- 4 capacitors and 3 inductors). The more poles, the deeper the cutoff will be, meaning the filter will act more efficiently. Try out WA4DSY's calculator using different pole configurations. You can see how the cutoff changes deeper the more poles included.

G3RJV doesn't specify the filter type in his article, but plugging the data into WA4DSY's calculator, the values he chose look most like a Butterworth configuration, so we can expect the db drop off similar to that chart.

This is the schematic for a low pass filter for 40 meters or for frequencies around 7 MHz:



There is a good chance you won't have any inductors or capacitors of the exact values specified handy; so, you need to make your own.

The capacitor values are simple. If you didn't already know, putting capacitors in parallel will add their values. So, for the two 270pF capacitors, I used the combination: 100pF + 100pF + 47pF + 22pF = 269pF. Close enough. For the 680pF I used: 470pF + 100pF + 100pF + 10pF = 680pF. Dead on! It's recommended to use either mylar or ceramic capacitors for filters.

For the inductors, you will need three T37-6 ferrite toroids and some 26 gauge magnet wire. If you don't have any T37-6 ferrite toroids, check out the links I posted here. You will want to wind two of them to 21 turns and one to 24 turns.

Also I should note, you could use different value toroids. What's important is the final inductance, not how it's made. If you use a different toroid, calculate or look up the correct number of turns to achieve the desired inductance. I will cover winding toroids and inductance further in a future post. For now, just make sure you evenly space the windings around the toroid, and leave a bit of space between the two sides. To strip the ends of the magnet wire, I usually use a lighter to burn the ends and use an x-acto knife to scrape the wire bare.

I initially laid the circuit out on a breadboard and was not achieving good results. The reason being, breadboards connections can add extra capacitance into a circuit. Whatever was happening was enough to throw my results off.

So instead, I chose to solder up the final circuit inside an Altoids tin, using dead bug style construction. I included SO-239 and PL-256 coax connectors, and used RG-174/u 50 ohm coax for the connectors. I also included a short length of coax from the side of the tin, as my Michigan Mighty Mite uses screw connectors to connect to the antenna.

This is the final result:

The best way to test the results of the filter is to use a [spectrum analyzer](). I don't own one or have access to one. In general they can be quite expensive. I did hook up the filter to my Michigan Mighty Mite, and saw that the RF watts output was the same as it was previously. It should output the same power for the transmit frequency and dampen power for higher signals. So, looking at that result and trusting in the physics at play here, I'm satisfied things are working properly.

Why filter out harmonics?

Simply put, it's good operating practice to filter out harmonics. If you are a radio amateur, you are only legally allowed to transmit on certain bands. If you are operating a transmitter throwing out harmonics, you may be unintentionally polluting the airwaves with your signal in places you never expected to hear it. Even if you flaunt FCC regulation and broadcast a pirate signal, remember that the airwaves are shared by commercial broadcasters, police, fire, EMS, and others, so it's important to filter out everything other than the desired broadcast frequency.

Posted: Aug 10, 2013

Keyword tags: altoidsfiltershortwaveHFtransmitterlow pass filter

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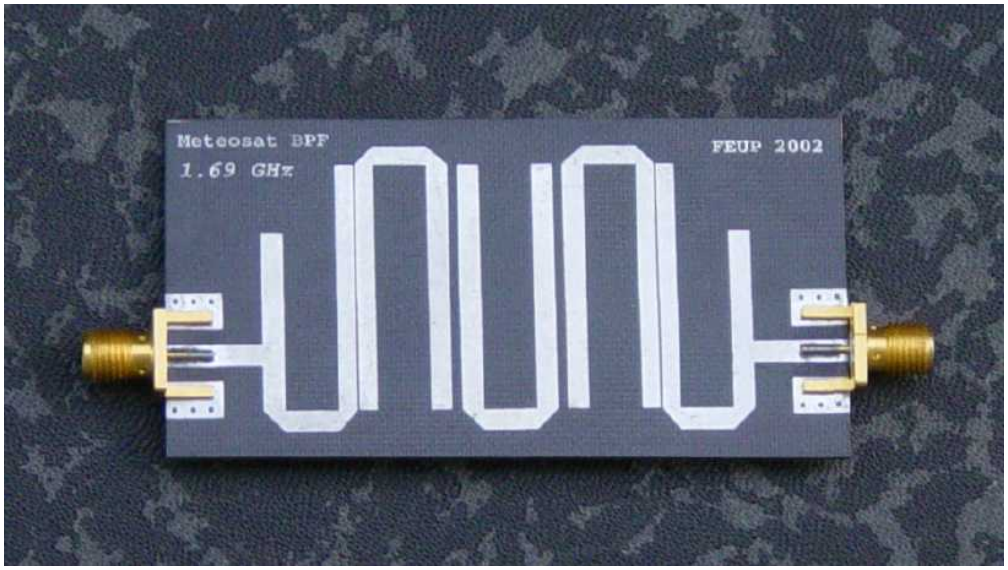
Microstrip Circuits

Hairpin band-pass filter (Equiripple, 3rd order, Fc = 1.69 GHz, BW = 100 MHz)

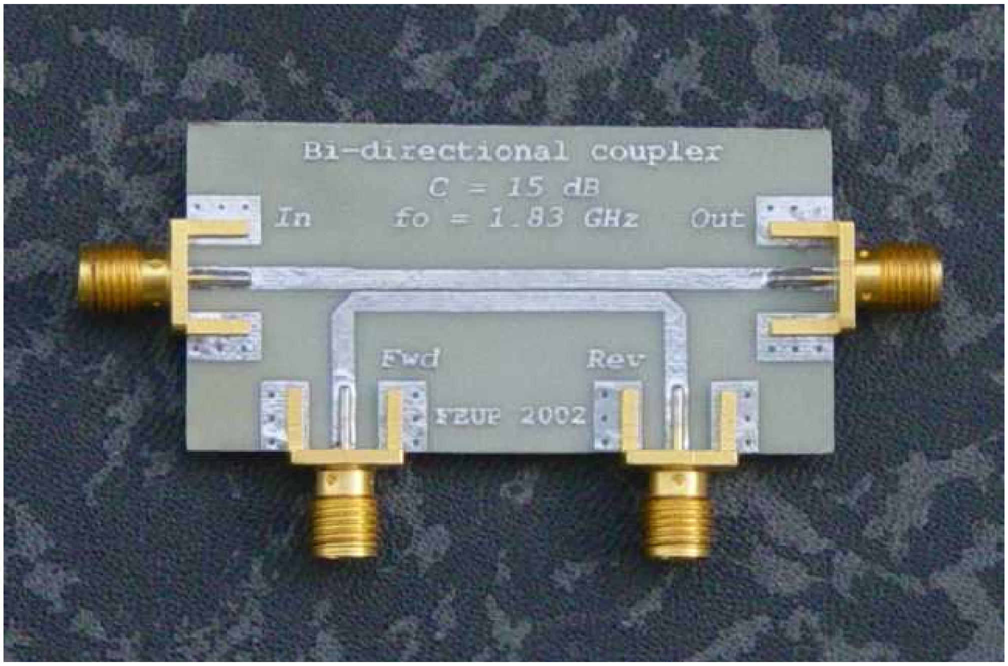


Datasheet

Coupled-line band-pass filter (Equiripple, 3rd order, Fc = 1.7 GHz, BW = 100 MHz)

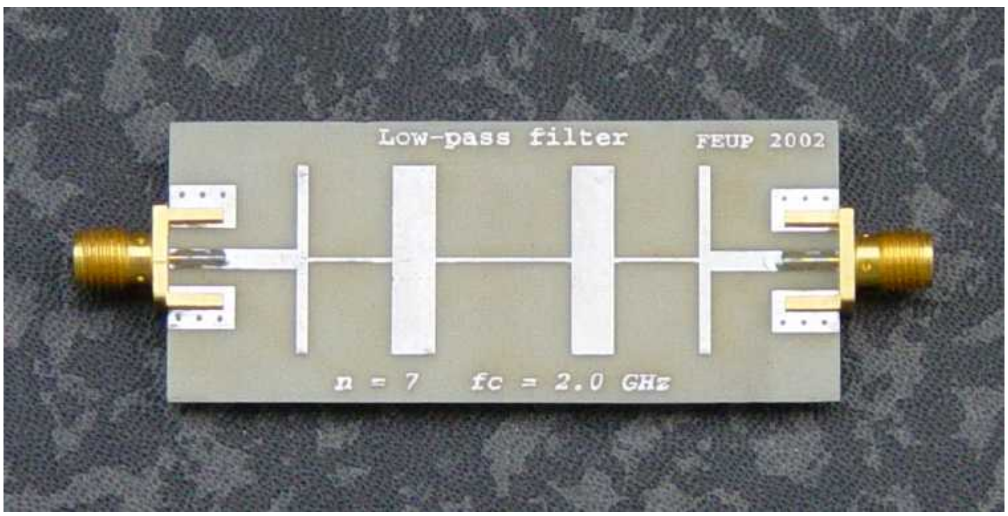
Datasheet

Bi-directional coupler (Fc=1.83 GHz, C = 15 dB)

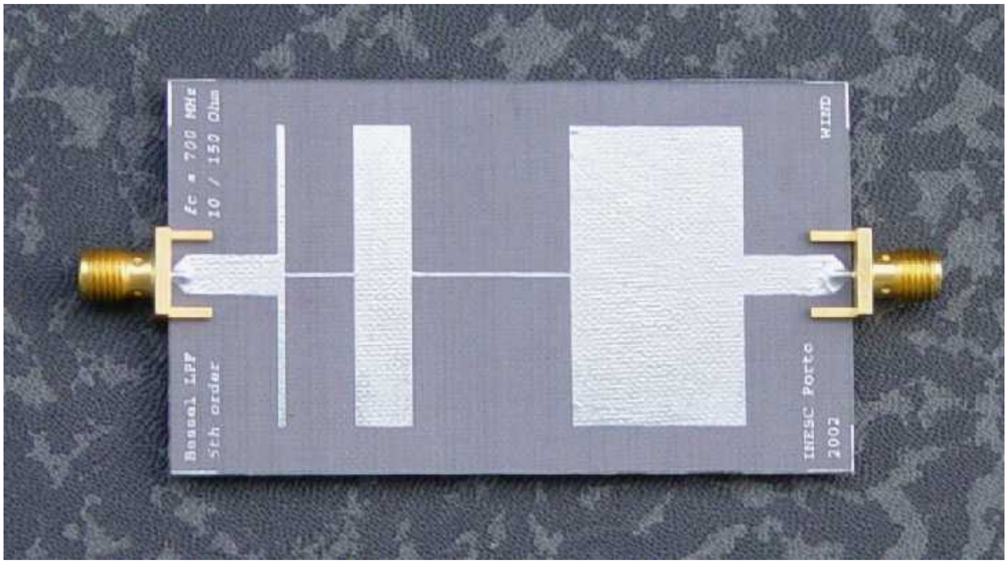


[Datasheet]

Stepped-impedance low-pass filter (Maximally flat, 7th order, Fc = 2.0 GHz)

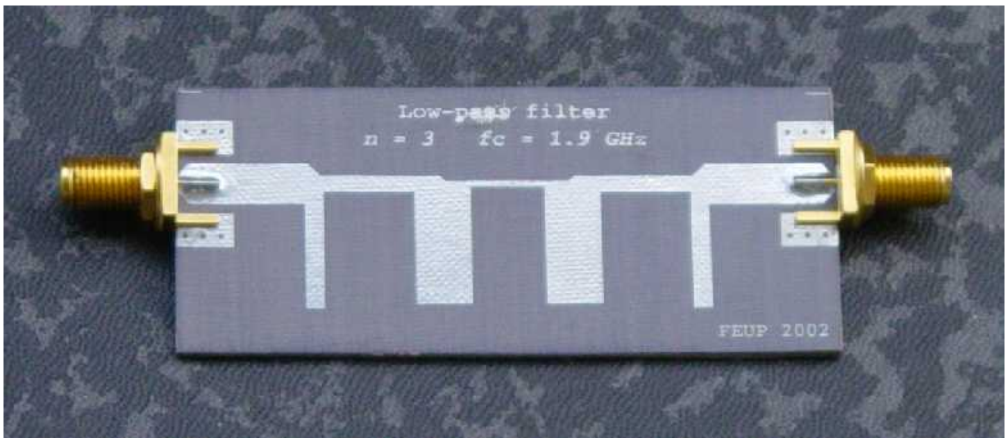


Stepped-impedance low-pass filter (Flat time delay, 5th order, Fc = 700 MHz)

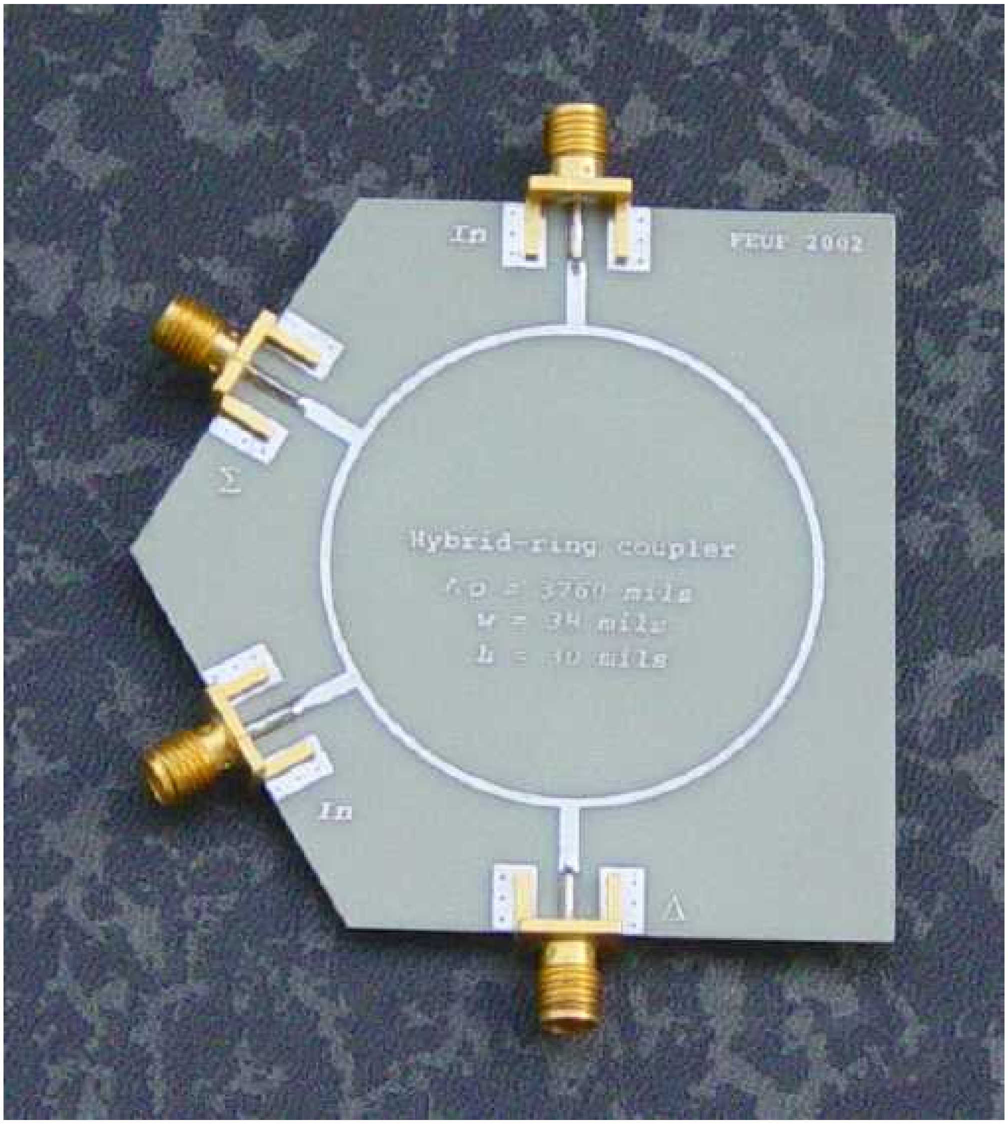


[Datasheet]

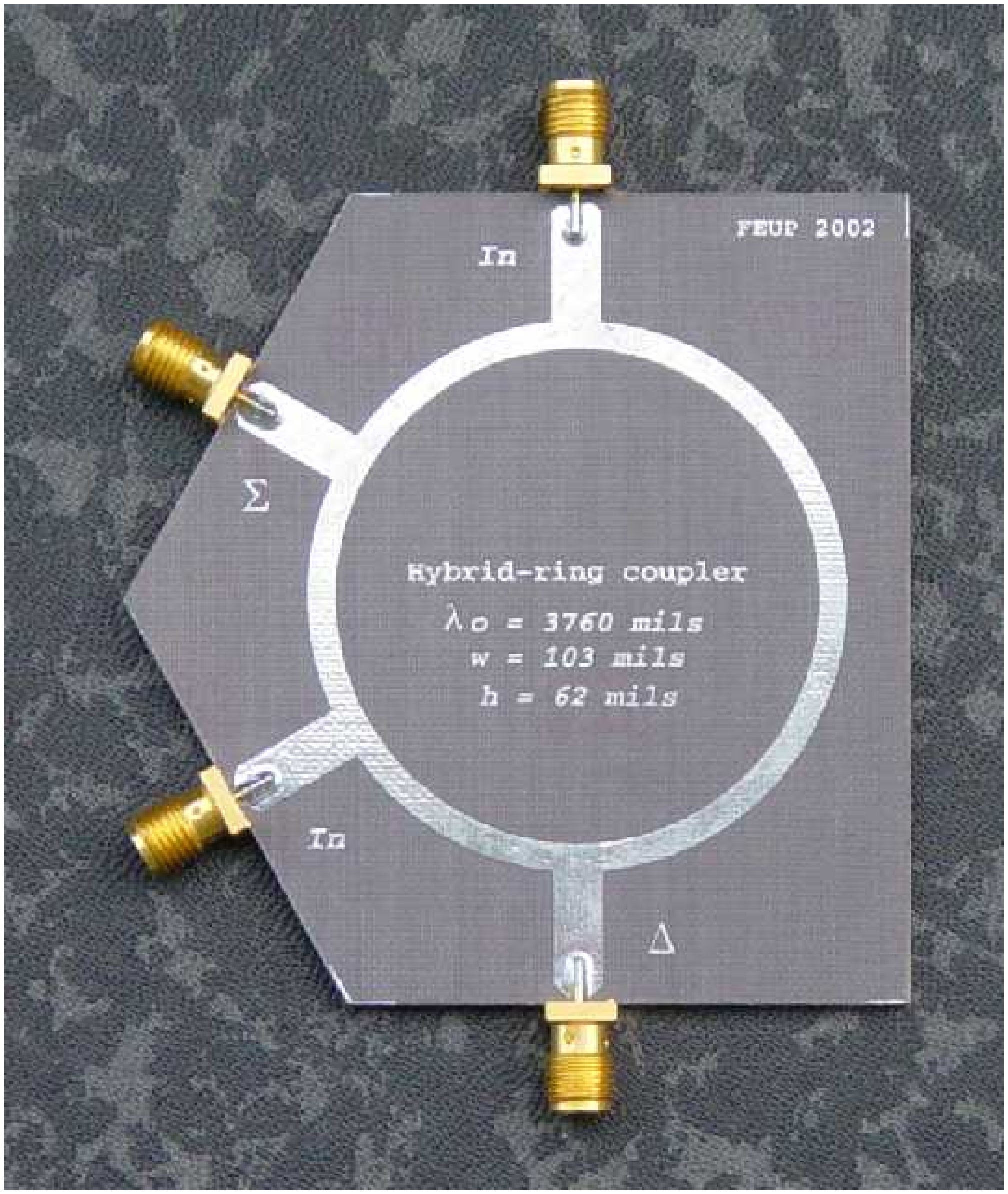
Commensurated-line low-pass filter (Equiripple, 3rd order, Fc = 1.9 GHz)



Hybrid-ring coupler (Fc = 2.0 GHz)



Hybrid-ring coupler (Fc = 2.0 GHz)



More to come:

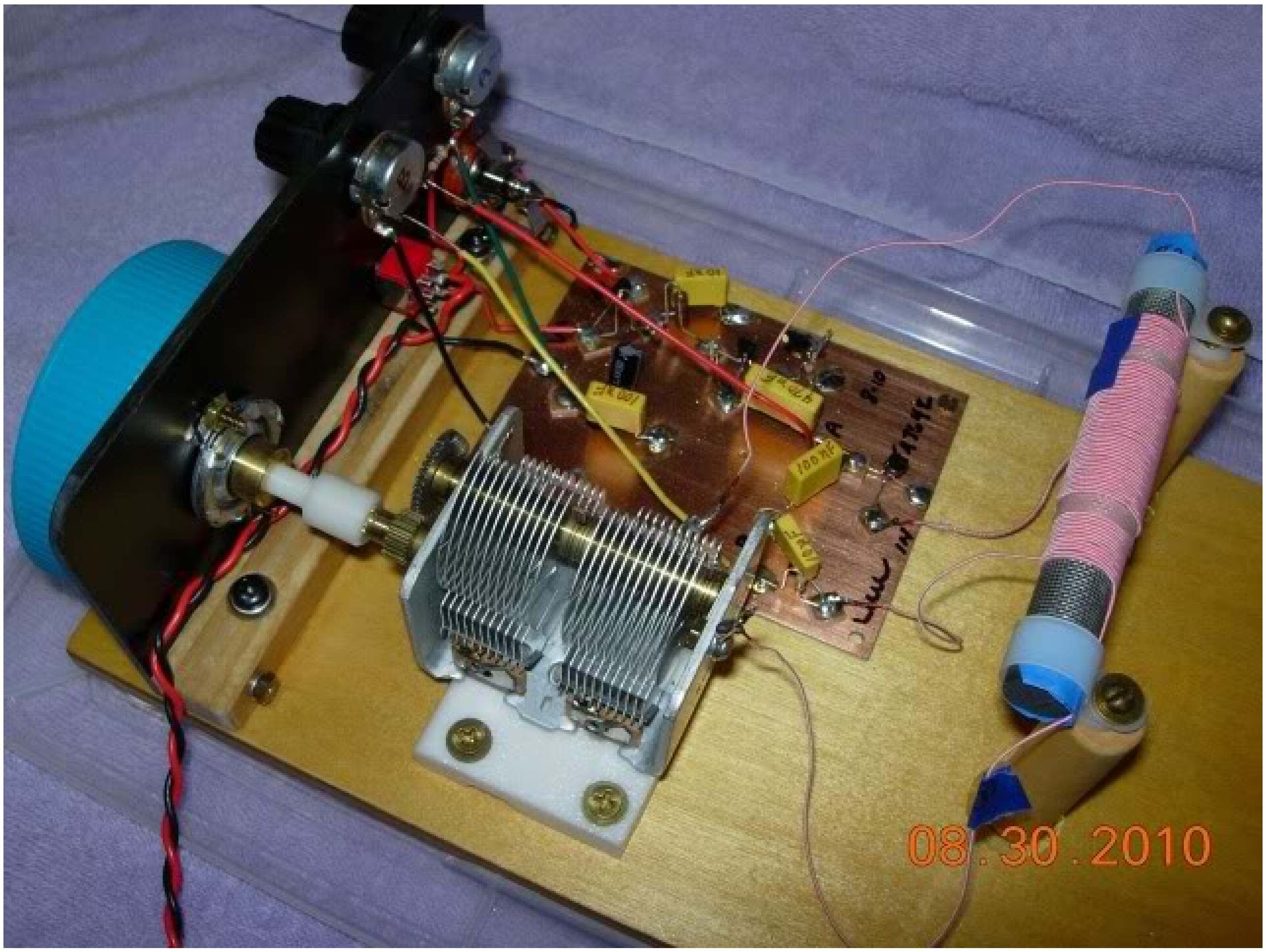
- Artwork files
- Network analyzer plots

Henrique Miranda, January 2003

MK484 Design Notes

By, Dan McGillis, WB3KBW

The complete thread can be found here:
http://theradioboard.com/rb/viewtopic.php?t=2791 (http://theradioboard.com/rb/viewtopic.php?t=2791)



A- (javascript:changeFontSize(-1)) A+ (javascript:changeFontSize(1)) (#)

Hi all. I’ve been wanting to play around with the “simple” radios based on the MK484 chip for awhile. Bruce Kizerian (ElmerDude) had kindly sent me some a few years ago and it’s about time to dust them off. Sorry if all this is “old hat”.

Reading-up on the MK484, its predecessor the ZN414, and successor the TA7642, I found that folks either love them or hate them. By far the biggest complaint is “they don’t behave well when faced with strong signals”. Those that love them seem to live in the country.

The data sheet for the currently available TA7642’s is no help with the “strong signal problem” -- not much there: http://www.rapidonline.com/netalogue/specs/82-1027.pdf (http://www.rapidonline.com/netalogue/specs/82-1027.pdf)

The data sheet for the older MK484 doesn't have much either: http://kitsrus.com/projects/mk484.pdf (http://kitsrus.com/projects/mk484.pdf)

BUT, the data sheet for the original design by Ferranti - the ZN414Z - is a gold mine: http://www.jaycar.com.au/images_uploaded/ZN414484.PDF (http://www.jaycar.com.au/images_uploaded/ZN414484.PDF) There's a hint in the operating notes on page 6 as to how to handle strong signals.

> It says: " — the gain of the ZN414Z is voltage sensitive so that, in strong signal areas, LESS (my emphasis) supply voltage will be needed to obtain correct AGC action. Incorrect adjustment of the AGC causes a strong station to occupy a much wider bandwidth — cause the RF stages to saturate — swamping – reduced AF output."

ie. – not well behaved.

Most of the MK484/ TA7642 circuits I've found use the recommended circuit shown on page 9 of the ZN414Z data sheet. This circuit places the same voltage on the power pin (the output pin) and the AGC line - which is the line through the 100k resistor and the tank coil to the input pin. So you have to reduce the chip supply voltage in order to reduce the AGC voltage -- they're hooked to the same voltage.

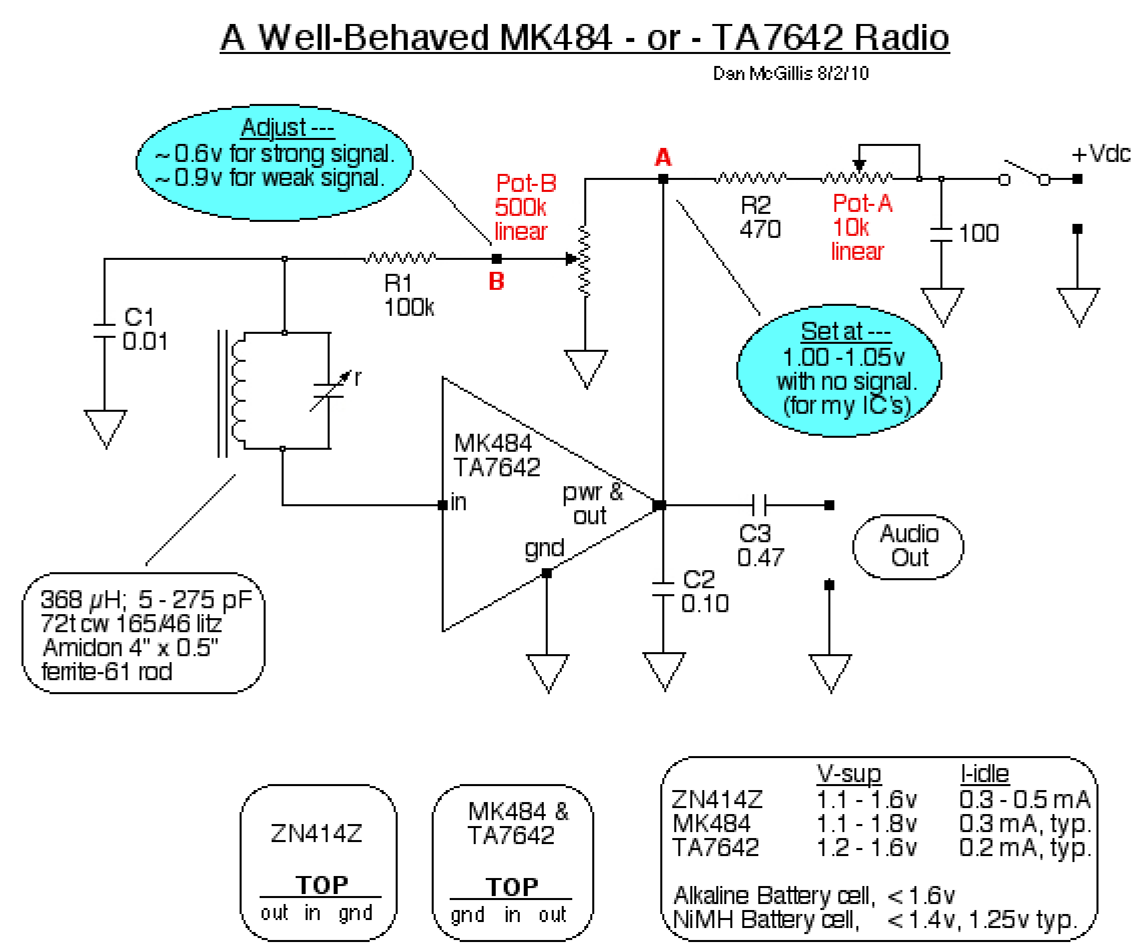
And that's another problem because the MK484/ TA7642 chips work well only over a fairly narrow range of voltage on the output pin. A voltage of ~ 0.9v seems typical. See for example the excellent article at: http://www.mikroe.com/old/books/rrbook/chapter3/chapter3g.htm (http://www.mikroe.com/old/books/rrbook/chapter3/chapter3g.htm)

I built several radios following, or slightly modifying, the data sheet circuit - and tried to put ~ 0.9v on the output pin by proper choice of supply resistor. But they all suffered from the "strong signal problem" - and frankly all of them were a pain-in-the-butt or so-so performers.

BUT– there's a solution to the "strong signal problem" in an ingenious circuit referenced in: http://cool386.tripod.com/zn414/zn414.html (http://cool386.tripod.com/zn414/zn414.html) It's called a "Performance Breakthrough" for the MK484 chip. And it is!

Evidently, in ~ 1986, the engineer(s) at a company called Technicraft developed a circuit that made the ZN414Z handle strong signals well. "They" (sure wish I knew who "they" were, to give them proper credit) broke the connection between the supply voltage and the AGC voltage. Each voltage can then be separately and EASILY optimized. Once you do that, the chip is VERY WELL BEHAVED for both weak AND strong signals.

Shown below is my version of "their" circuit – and it works like a champ, at least for the 2 different MK484 chips, and the 2 different TA7642 chips I tried.



The separated voltages Va and Vb, and the 2 pot adjustments make a HUGE difference.

The trick to setting up the chip supply voltage, Va at point “A”, is to quickly evaluate how a particular chip (and circuit) behaves. Here’s what I did.

1.) Set the AGC voltage at point “B” to 0v using Pot-B. That’s like having “no signal”.

2.) Adjust the supply voltage at point “A” to a PRECISE value - like 1.05v - using Pot “A”.

3.) Now increase the AGC voltage to about 0.8 - 0.9v or so by adjusting Pot “B” - and start tuning around the band from 530 kHz to 1700 kHz.

NOTE that once you tune-in a signal, you can increase or decrease the volume by adjusting Pot “B”. NEAT!

4.) Take note of the apparent bandwidth and sensitivity as you tune across the band. They change as you go from 530 kHz to 1700 kHz.

5.) Now, reset the voltage at point “B” to 0 again, and adjust the supply voltage at point “A” to a new value using Pot-A. And repeat the above procedure - noting the apparent selectivity and sensitivity. It doesn’t take long.

Here’s an example of the kind of quick characterization I did for each chip:

MK484 #1.

Va = 0.90v; Too sensitive, tends toward instability, Pot-"B" adjustment "touchy".
Va = 0.95v; Excellent sensitivity & selectivity across whole band. Pot-B not "touchy"
Va = 1.00v; Excellent sensitivity & selectivity across whole band.
Va = 1.05v; Selectivity somewhat degraded at high end of band.
Va = 1.10v; Poor selectivity, lower sensitivity at high end, OK at mid to low end.

"Conclusions:

— The "good" operating range for Va is pretty small!

— The target Va for this chip (and circuit) is Va = 1.00v +/ - 0.025v. Use Pot-A to dial-in this optimum supply voltage. Re-adjust Pot-A as the battery ages. No problem."

All 4 chips I played with behaved pretty much the same - except:

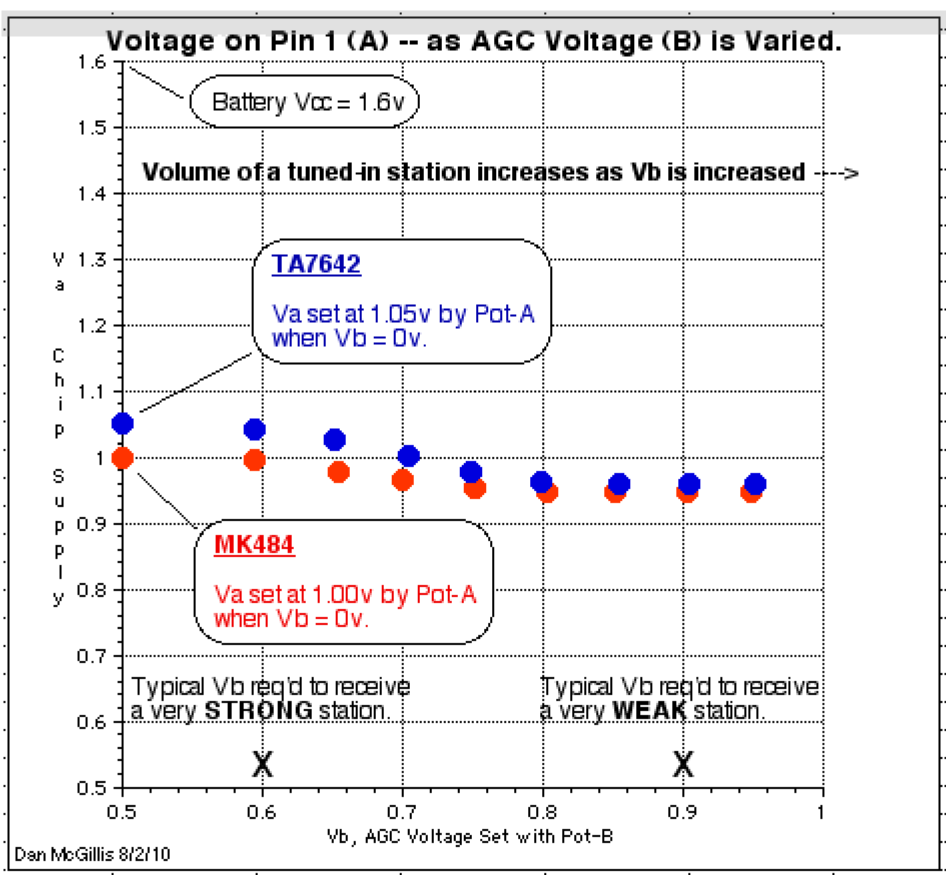
— the MK484 chips had noticeably better selectivity, but less sensitivity than the TA7642's;

— the MK484 chips seemed closer to oscillation than the TA7642's. I could hear the "sea shell" affect in the audio. Reducing the 100k AGC line resistor lessened the tendency, but I left it at 100k.

— the TA7642 chips had a slightly wider "good" supply voltage operating range (Va) than the MK484 chips.

You adjust Pot-B, if necessary, to change the AGC voltage to suit the station you're tuned to - weak or strong. When Pot-B is changed, the supply voltage Va on the output pin is also slightly changed from it's "set" value. Hopefully, it does not get out of the preferred range as determined during the chip characterization exercise described above.

In the graph shown below, I've plotted the way the chip supply voltage on the output pin (Va) changes as the AGC voltage at point "B" is changed - by varying Pot-B.



There are a couple of things to note about the graph:

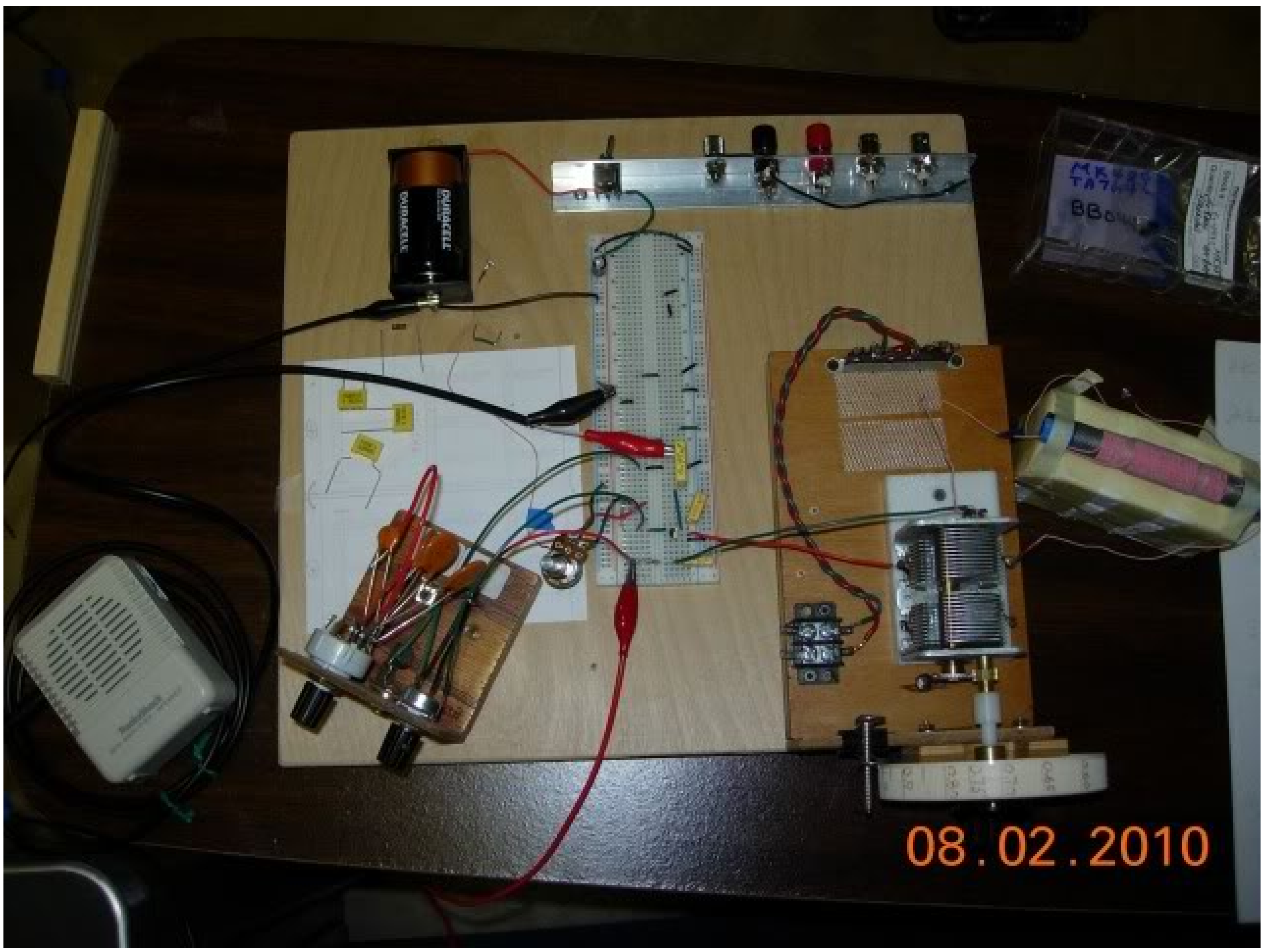
1.) The voltage Va changes as Vb is varied - but seems to stay in the “good” range.

2.) You need an AGC voltage at point “B” near ~ 0.6v to tame very strong stations.

3.) Very weak stations - even right next to strong stations - can be heard by increasing the AGC voltage at point “B” to near ~ 0.9v.

Ordinarily, in the “standard” MK484 circuit, if you had set Va = 0.9v --- then Vb would also be 0.9v, and the radio would respond well to a weak signal, but have trouble with a strong signal.

I’ve included a picture of my setup, --- it’s a mess. But it works very well. I suppose it demonstrates that the MK484 & TA7642 are more tolerant than we think.



Without an antenna - just the 4” ferrite rod – and in the basement, the “mess” can easily pick up my moderate – to – strong daytime stations, and a few weak ones too.. And at night, it hears - and separates - lots of DX.

With an antenna/ ground to a Tuggle tuner — lightly coupled to the MK484/ TA7642 tank, the “mess” becomes a hot DX radio. And it’s a well behaved hot DX radio.

Thanks for putting up with another long-winded post. I get excited about these “simple” radios ‘cause it’s all new to me. And great fun.

Hi all. **Here’s an update.**

1.) Reduced the Vcc supply to an AA rechargeable battery (1.33v). I’ll let this run continuously for a few hundred hours to see how the set handles a drop in voltage and increased battery resistance.

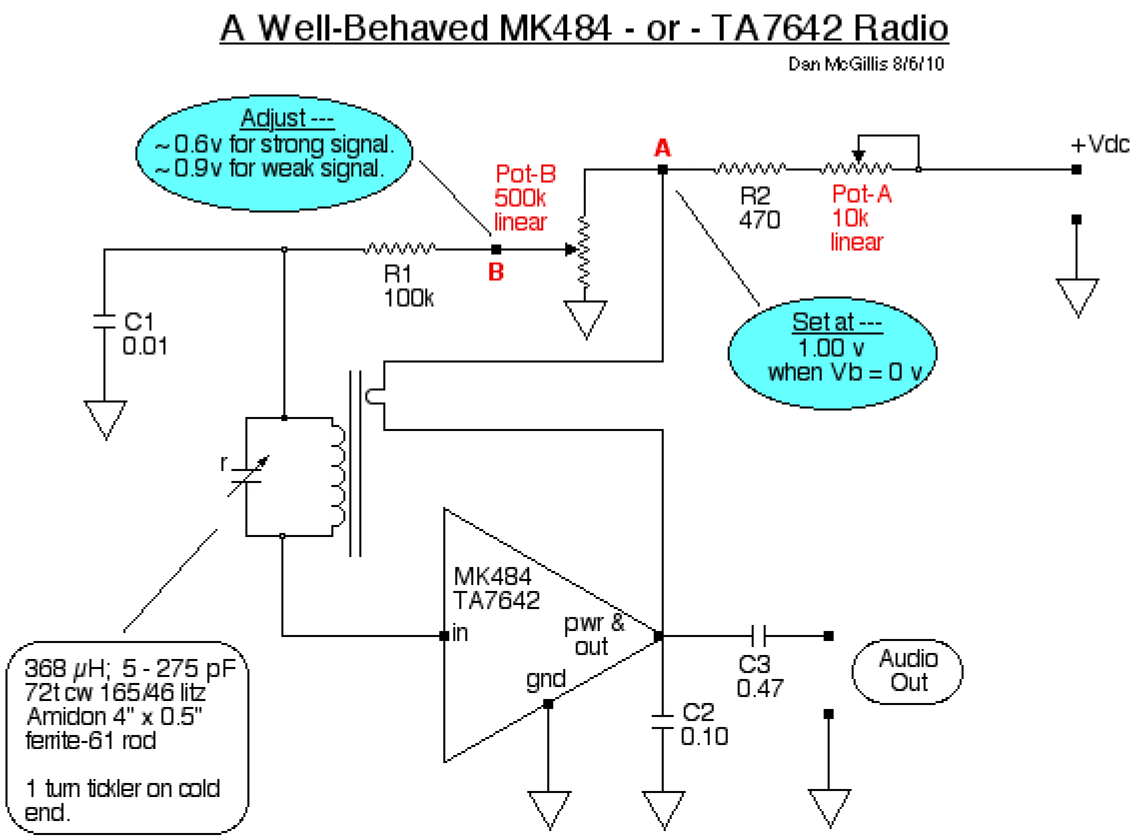
— Eventually, if all goes well, I’d like to put a solar cell on the radio to trickle charge the battery. 2.) Added just a touch of + feedback to narrow the selectivity a bit. It also reduces the audio bandwidth a little which helps my bad ears. I don’t know if this is really worthwhile or not -- have to play with it some more. It’s fun to fiddle with.

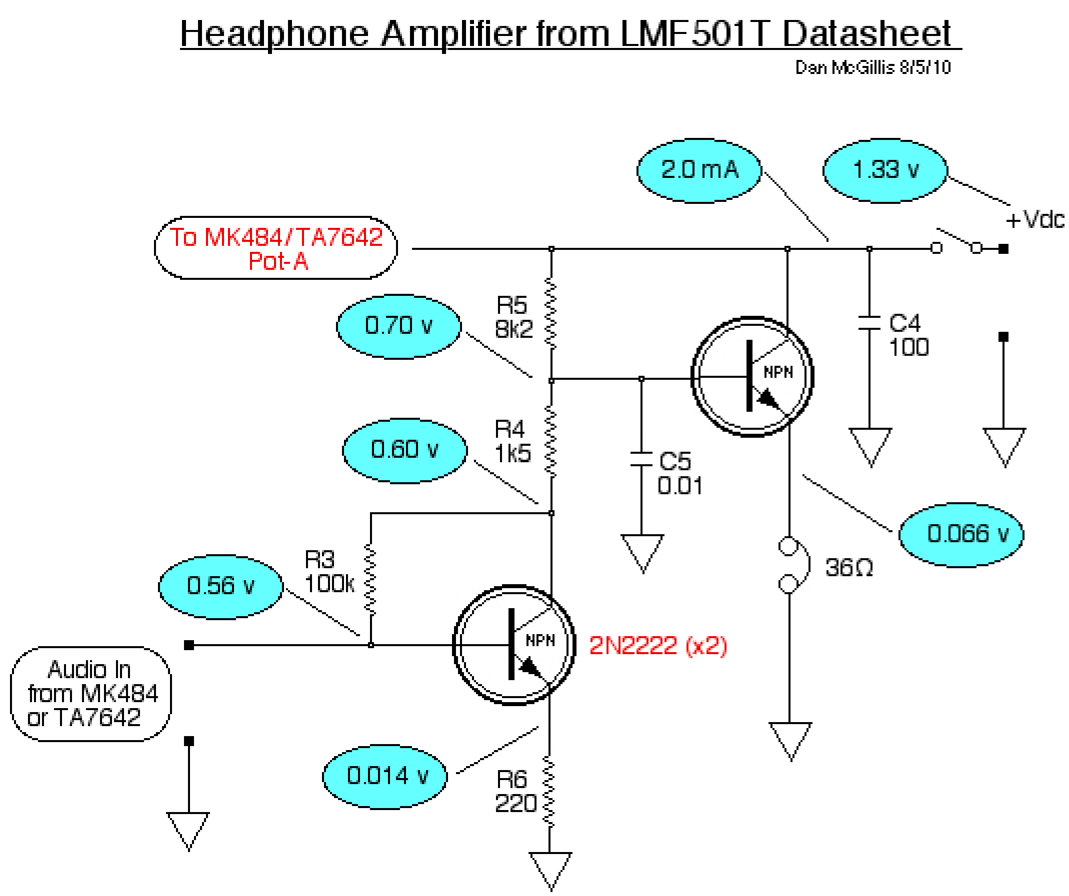
3.) Added a headphone amplifier as described in the LM501T data sheet. (Thanks WA4QAL, Dave.) I had tried a few others, but this worked about the best – at least for this setup. Plenty of volume even for night time DX.

— A “Walkman” type headset is used with the amp. Very comfortable. All I have is a flea-market unit that measures ~ 36 ohm per element. I’m only using one element -- eventually I’ll wire both elements in series to give ~ 70 ohms and maybe pick up even more volume.

4.) Put the whole thing on a “Lazy Susan”. The radio can be easily rotated since there is no external antenna or ground hook-up.

— This REALLY helps null-out a particularly loud daytime station 3 miles away. At night - when they reduce power - it’s not needed. It’s kind of fun to rotate the thing and play “direction finder” games.


A Well-Behaved MK484 - or - TA7642 Radio
Dan McGillis 8/6/10
Adjust ---
~0.6v for strong signal.
~0.9v for weak signal.
Pot-B
500k
linear
A
R2
470
Pot-A
10k
linear
+Vdc
R1
100k
B
C1
0.01
Set at ---
1.00 v
when Vb = 0 v
r
MK484
TA7642
in
pwr &
out
gnd
C3
0.47
Audio
Out
C2
0.10
368 μH; 5 - 275 pF
72t cw 165/46 litz
Amidon 4" x 0.5"
ferrite-61 rod
1 turn tickler on cold end.


Headphone Amplifier from LMF501T Datasheet
Dan McGillis 8/5/10
2.0 mA
1.33 v
+Vdc
To MK484/TA7642
Pot-A
R5
8k2
0.70 v
NPN
C4
100
R4
1k5
0.60 v
C5
0.01
0.066 v
36Ω
R3
100k
0.56 v
NPN
2N2222 (x2)
Audio In
from MK484
or TA7642
0.014 v
R6
220

Hi all. This bypass & decoupling info is probably well known - but I'll pass it along anyway because I had a good time learning about it the hard way.

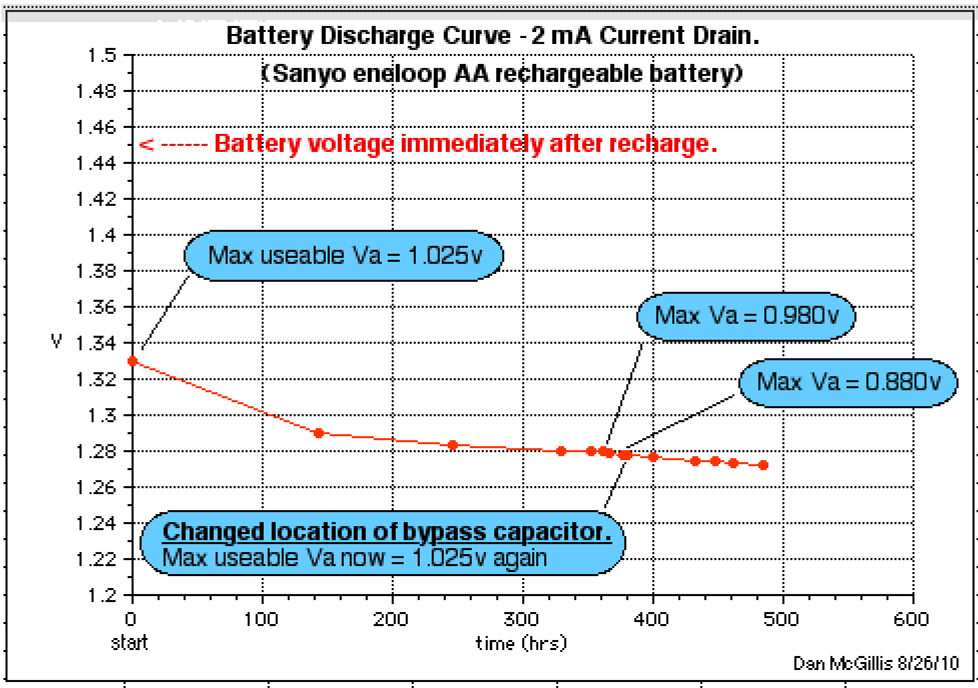
After fiddling with and listening to this little radio for awhile, I ran into my first glitch.

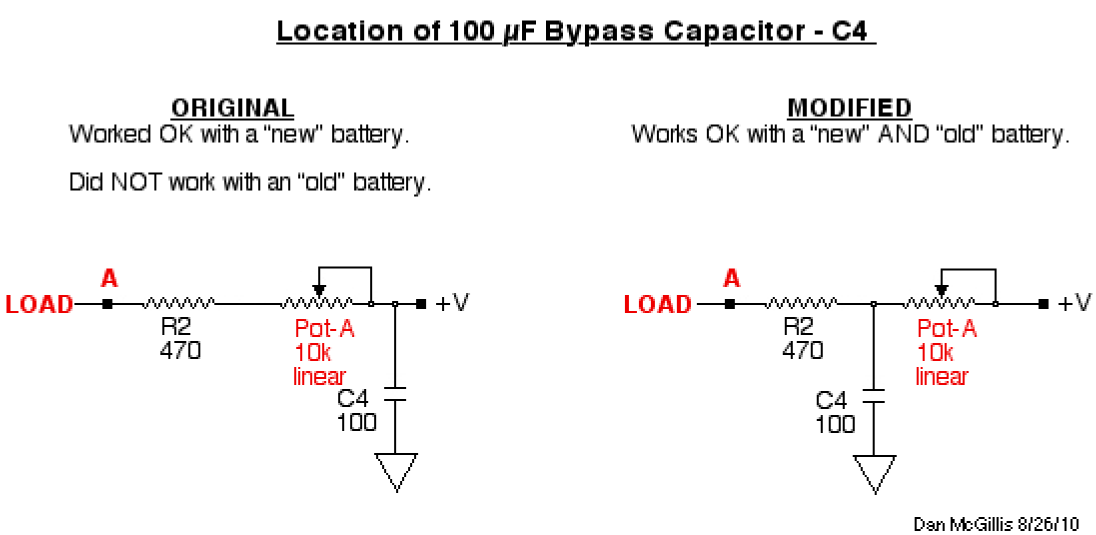
The radio has been running continuously off of a used rechargeable AA battery. I wanted to see what happened as the battery aged and it's internal resistance increased.

Sure enough, after about 360 hours of run time, the radio started to "act up" in the form of bad audio distortion. At first, I cured the problem by adjusting Pot-A to lower the supply voltage "Va" to the TA7642's output pin. This also reduced the radio's sensitivity -- not good.

But within 24 hours I had to reduce Va again as distortion crept back in again. Va was now so low that the radio's sensitivity was seriously compromised.

Shown below is a plot of the battery's output voltage over time - AND the points at which I had to reduce Va to get rid of audio distortion that kept creeping back in.





The idea behind the location change is discussed by Ken Kundert in his article “Power Supply Noise Reduction”: http://www.designers-guide.org/Design/bypassing.pdf (http://www.designers-guide.org/Design/bypassing.pdf)

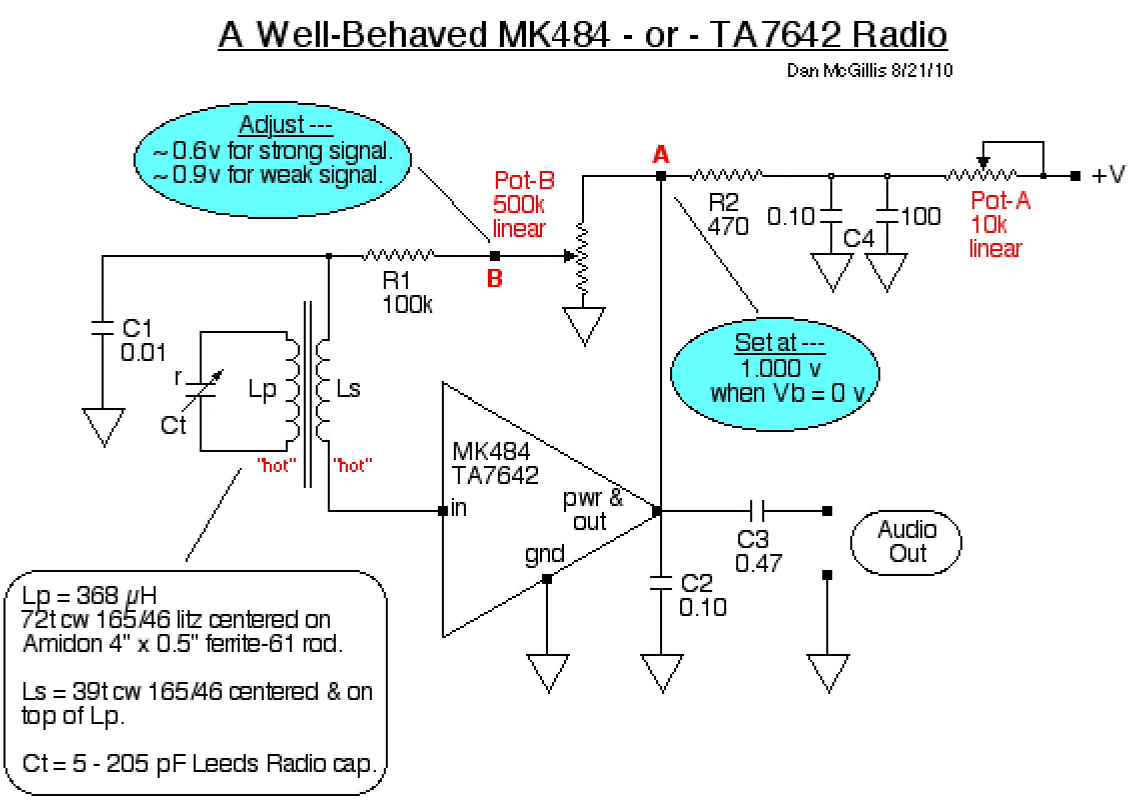
See especially Figure 6 and his discussion of decoupling.

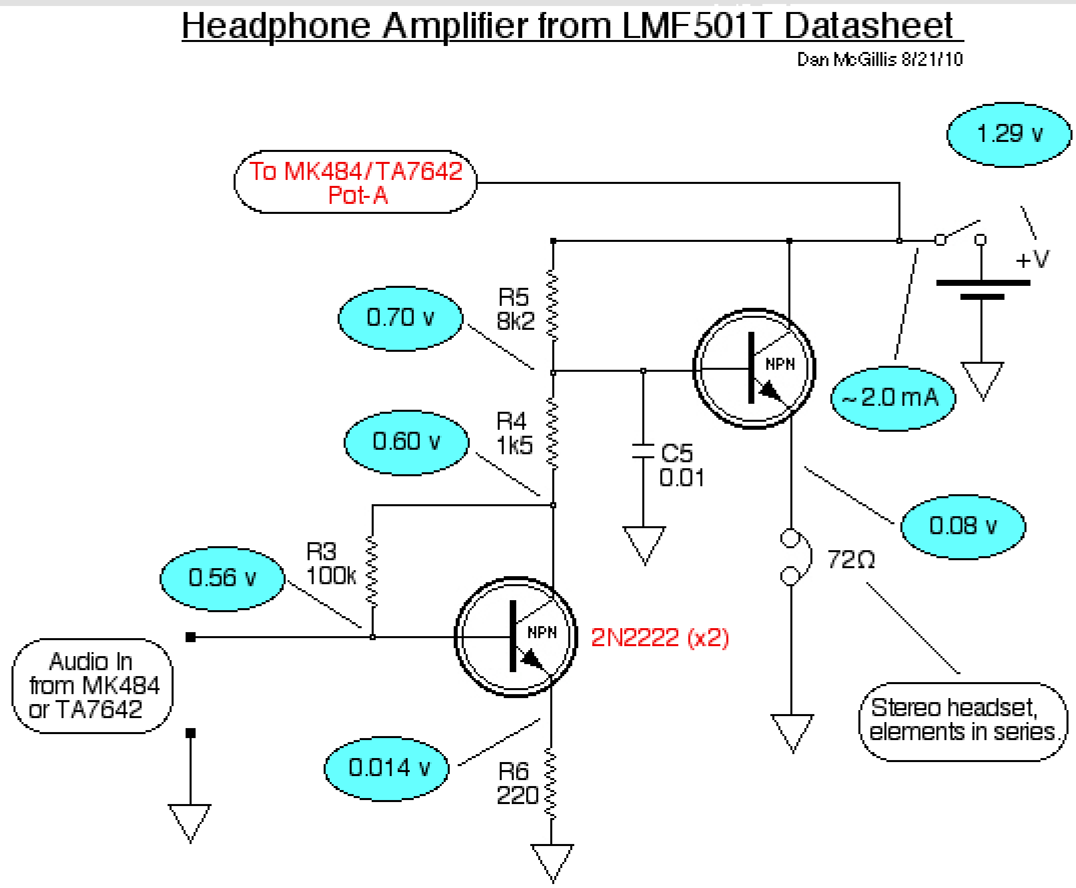
I think the “cure” explanation is (trying to paraphrase Ken):

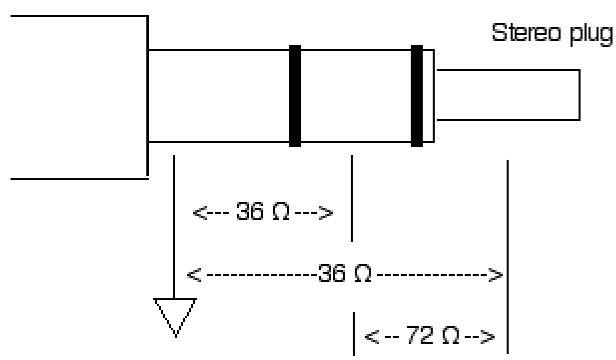
— Shifting the location of the bypass capacitor (C4) places the “high” resistance Pot-A in the supply line BETWEEN the battery and the bypass capacitor. This FORCES high frequency noise current from the TA7642 circuitry load to flow through the low impedance bypass capacitor rather than the battery.

IF the high frequency noise currents reach the battery, and IF the battery is “old”, - ie. has a high internal resistance - sufficient high frequency noise voltage is generated on the supply line to affect the circuits connected to the battery. ---

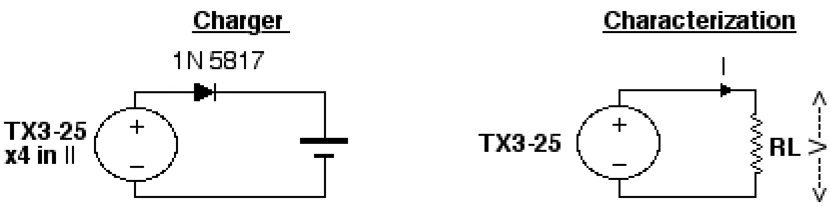
Here’s the TA7642 (MK484, ZN414) final:

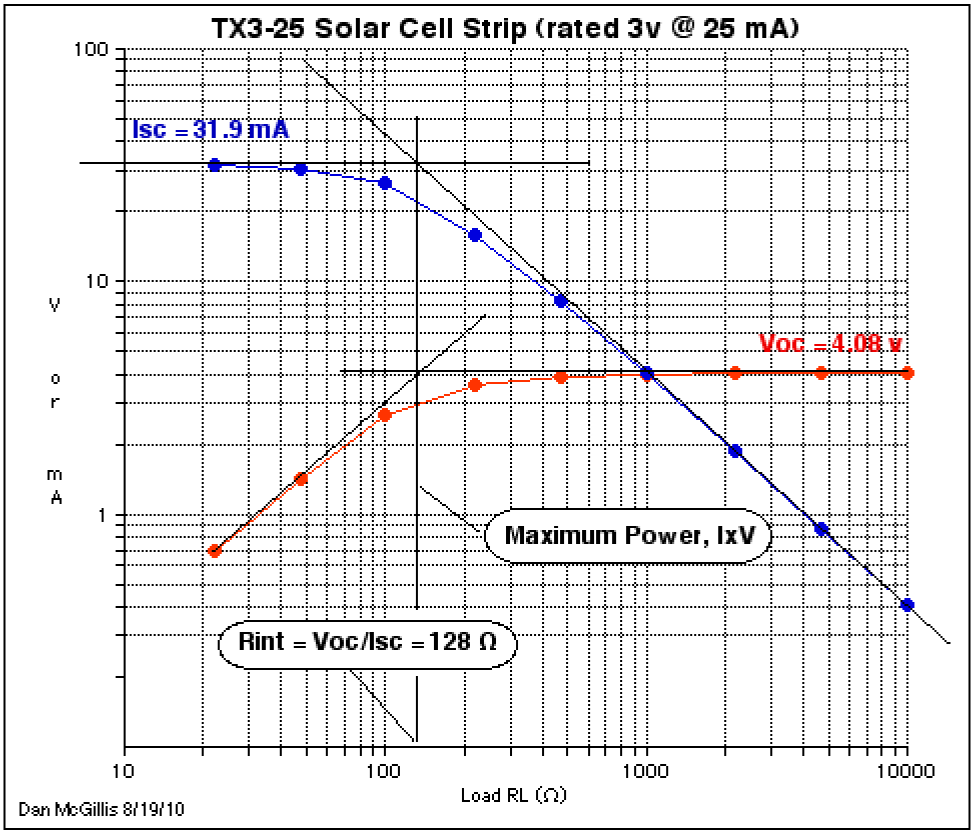






Wire-up a stereo jack using only the 2 speaker connections - NOT the common ground connection. This puts the headphone speakers in series giving a 72 Ω load.





The data was NOT taken at maximum illumination (local noon, but not tilted) so the Isc is a tad low.

The data shows how the load RL on the cell affects the output current and voltage. The graph also shows how:

— Isc, the short-circuit current,
— Voc, the open-circuit voltage,
— Rint, the cell's "internal resistance" (assuming the simple emf model), and,
— the maximum IxV power conditions,

are all related. You can see from these curves how the cell gets it's "3-25", ie 3v-25mA, rating.

Fun stuff.

73, Dan

The complete thread can be found here: [http://theradioboard.com/rb/viewtopic.php?t=2791 (http://theradioboard.com/rb/viewtopic.php?t=2791)](http://theradioboard.com/rb/viewtopic.php?t=2791)

A low power AM transmitter for the Broadcast Band

A comprehensive story containing technical elements & personal opinions
by
John Fuhring

Warning!!

The following section contains my political and religious views, prejudices and opinions that some may find offensive

Please skip down to the Technical Section if you don't like reading this kind of stuff.

Why I needed an AM transmitter

I stopped listening to AM radio decades ago, but around 1998 I wanted to put together a crystal radio kit for my nephew in an attempt to get him interested in radio as I had been at his age. As I was experimenting with plans for a good but easy kit, I was shocked to discover what the band had degenerated into. Locally there are two Spanish language stations, two obnoxious "Christian" Fundamentalist stations and two stations that broadcast right-wing hate-talk propaganda day and night. For a long time now, there has been nothing useful, entertaining or intelligent to tune into on AM (unless you speak Spanish). I sincerely wish I spoke Spanish and liked Mexican music because the Spanish stations seem like "Islands of Sanity" in the otherwise sea of pure crap that's out there.

In America, broadcasting is all about feeding "the audience" what they want to hear so that they will listen to the advertisements. English language AM panders to the ignorant and prejudiced people of my community who are afraid that their "superior" culture and foolish myths are under threat. For comfort and reassurance that their distorted vision of "America" is always right, they tune in to this nasty stuff and the truth is, they are pretty loyal listeners. Having all those dumb people listening so loyally really attracts the advertising dollar and so between hate-talk rants by Limbaugh, Savage Wiener, Beck and our own local wannabe, Andy, the airwaves are filled with the most asinine advertisements. I mean, these are advertisements that, for the most part, should grossly insult the intelligence of the severely retarded.

For a long time now, I could not have cared less if AM disappeared altogether because I had my FM radios for entertainment. Well, all that changed when my long dormant interest in antique radios recently resurfaced. While getting these old radios back working, I began to listen once again to some of our local trash and sadly rediscovered that, if anything, AM is even worse today than it has ever been. Oh lord, I thought the hate-talkers were bad when Clinton was president, but now that we have a *black-man in the White-house*, in my life, I have never heard such over-the-top hatred. It's just disgusting, but that's what our "local talent" wants to be fed, so there it is.

So, what's a guy going to do when there is nothing decent to listen to? Well, one thing I do is to wait until after sundown and on those few nights when the "skip" is in, I tune in a great old station up in San Francisco, KGO radio. Listening to KGO reminds me that once AM was worth listening to, but KGO isn't all that easy to hear. Most nights the skip isn't there and you can't hear it at all. Even when the skip is in, the signal is subject to fading, interference and noise. Then there is the fact that even KGO plays endless commercials. I must admit that KGO's commercials aren't quite as stupid nor do they assume the kind of listener stupidity that the local right-wing stations do, but those endless commercials really get tiresome and annoying. Oh god, those "Cars For Kids" jingles just make me cringe, **CRINGE!!**

Since writing the above, and for some months now, I am sad to report that even old KGO, a station that first went on the air in 1924 and was once the pride of Northern California, has joined the ranks of the AM zombies and is now hardly worth listening to. For reasons of greater profits, the station has eliminated its program hosts and has gone to an "all news and traffic" format that includes recorded business reports from outside vendors. Obviously the management does not care that the radio station has lost most of its listeners because, even

with fewer listeners, the station is more profitable now that they have to hire so few employees. In making the decision to downsize and eliminate most of the employees, the CEO of KGO certainly did not do the people of their community (or me) any favors, but in America today, squeezing out the last bit of profit is the highest of all virtues. The responsibility to hire good people and to enlighten the community with good programming is rejected as a quaint old notion that no businessman today would give a second thought to.

OK, I've had my say regarding KGO. Actually, what happened to KGO is just the final act in the death of English language AM radio in America and it illustrates my point.

While meditating on what has happened to AM radio, I suddenly became "enlightened" and I would like to share my "enlightenment" with you in the form of some Noble Truths:

The

Four Noble Truths

of AM radio as it exists today

(1) Listening to local AM makes my skin crawl after about two minutes.
(2) AM radio is such a pain because all the local stations have been taken over by obnoxious religious and political propagandists.
(3) There is an escape from what is so annoying about local AM radio.
(4) You may escape this annoyance through broadcast band DX'ing late at night or, better yet, by having your own small
AM transmitter and broadcasting your favorite stuff (or rebroadcasting your favorite FM station) to your old radios.

I think you will agree that having your own AM transmitter is pretty important, so it is the latter part of the Fourth Noble Truth that this article is all about.

Buy or build your AM transmitter?

All of us have experienced the wisdom of the old saying: "If you want something done right, you have to do it yourself." Well, I have made up an old saying too: "If you want something done at ALL, you have to do it yourself." Taking that aphorism and applying it to my situation, I have concluded that if I wanted something entertaining to listen to during the day and on most nights, I would have to broadcast it myself, but to do that, I would have to have an AM broadcast band transmitter.

There are all kinds of transmitters that one can buy. These sets range from very cheap kits that have poor coverage to expensive sets that get mixed reviews. On the Internet, you can find several plans for sets that you have to build up from scratch. Well, I really hate "reinventing the wheel" when it comes to this sort of thing, so I searched around and found what I thought was "the most-est and the best-est for the least-est" in the form of the SSTRAN AM transmitter. The specs looked good and the seller said it was good, so I decided to get one.

I sent them my order and paid for it and then I waited, and waited and waited. Finally, after almost two weeks, I received notice that it had been shipped. I was angry at what I perceived as poor response and so I very stupidly wrote a less than nice E-mail to complain about SSTRAN's tardiness. You know, it comes as a kind of a shock to me when I discover that there are people out there who are as nasty or even nastier than I am. A certain Mr. Bolyn (who I assume owns SSTRAN) took great offense at my intemperate remarks and in a remarkable show of fast action, never before seen, he pulled my order right then and there.

You see, when I was notified that my package had been shipped, this wasn't quite true. In truth, my order was only "**ready**" for shipment and therefore Mr. Bolyn could indulge his bad temper as he saw fit and interdict my order. I toyed with the idea of writing back to apologize for criticizing his operation and asking him to please, please, please send me the radio. Well, after his nasty little trick, that wasn't going to happen and besides, there were other considerations that kept me from asking Mr. B to relent. In the end I decided I didn't want his product after all so I replied by informing him that I thought that his business practices were despicable and I'd make my own radio, thank you very much. As far as I'm concerned, letting petty emotional pique interfere with good business practice **is** despicable and I certainly do not recommend anybody having any dealings with this person or his company. In fact, I don't recommend anybody have any business dealings with me either, but

then this is a non-commercial website and nobody is charged a cent for anything here.

By waiting all that time and then having the order pulled at the last second through some nastiness on both our parts, I had wasted many days and I still didn't have an AM transmitter. Falling back on the old saying I had made up about doing things yourself if you wanted them done at all, I searched the Internet for a project that I could quickly put together. One site that kept popping up was Charles Wenzel's page where he describes his AM transmitters. The more I looked at Mr. Wenzel's designs, the more I liked them and finally decided that I would build something similar.

I sent an E-mail to Mr. Wenzel and I was both surprised and delighted at the promptness, the politeness and the extent of his reply. Through a series of extremely helpful exchanges, I finally settled on the design that will be the topic of the remainder of this article. By the way, anyone familiar with Mr. Wenzel's page will immediately see that I have pretty shamelessly ripped off his clever design, but you know what they say, "imitation is the sincerest form of flattery."

As I write, I have indeed built one of Mr. Wenzel's transmitters and it works great. The only regret I have is that I didn't "bite the bullet" and start this project earlier. I sincerely wish that I would have started this project before wasting all that time dealing with that SSTRAN outfit. Yes, making a radio up from scratch, getting all the components, winding the coils, laying out a circuit board and all that is hard work and very time consuming, but when you are done you have saved days and days of waiting, a pile of money and you have the satisfaction of having something that you built yourself. This satisfaction is really enhanced if the finished project looks good and works well too. I can truthfully say that my little transmitter fits both of those categories.

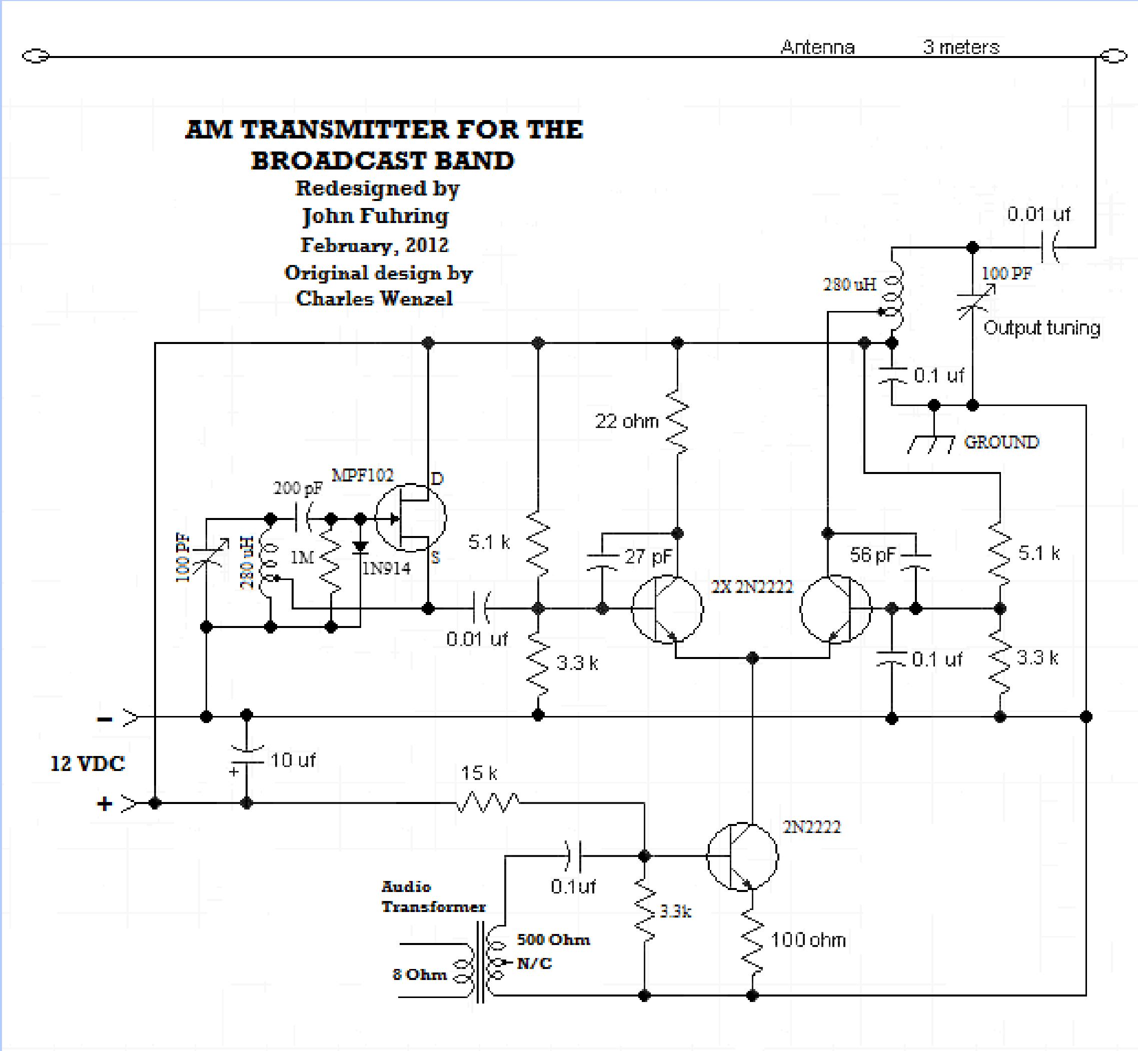
Technical Section

How the transmitter works

In my analysis, the heart of Mr. Wenzel's design is a trio of NPN transistors. These transistors include a VFO buffer amplifier, a RF amplifier and a modulation amplifier, all feeding into or out of a common bus. I was immediately struck by how simple, but how clever this arrangement is and soon I will describe my understanding of how this trio works together. Before I get into that, I want to say something about the Variable Frequency Oscillator (VFO) I'm using in this design.

If you will examine Mr. Wenzel's design and then mine, you will notice that I do not use the crystal oscillator he recommends. To generate the carrier frequency, I use a VFO. I did that for two reasons: (1) I don't have access to crystals of the right frequency and (2) I wanted to be able to tune to anywhere on the broadcast band where there might be a quiet spot. The VFO I'm referring to is the coil-capacitor & FET circuit shown on the left side of the schematic diagram below.

I just love this kind of oscillator circuit because it is simple to build, it has good frequency stability and it puts out a very clean, harmonic free signal. It is a simple Hartley oscillator with the usual tapped tuning coil, but it is a little unusual because it has a high speed diode in the gate circuit that does a marvelous job of automatically biasing the transistor. This self-biasing feature is so important because it insures that the transistor can't go into run-away and produce spurious frequencies. As you can see, the diode is arranged to produce a negative voltage on the gate that is proportional to the signal level. A signal level that might be too high creates a large negative bias that automatically limits the transistor so that it stays within its linear range. So simple and yet so effective and that is a form of elegance that I greatly admire.



A practical AM transmitter
Design adapted from Charles Wenzel with modifications.
Note that I am using commonly available components.

The 'carrier' signal generated by this circuit is tapped off at the low impedance point where the FET's 'source' is connected to the coil's tap. Kind of clever that this point is called a 'tap' don't you think? See, the signal is 'tapped' off at the 'tap' -- get it -- oh never mind.

From there the carrier signal feeds the base of the left-most NPN transistor. This transistor is the buffer amplifier that I mentioned earlier. This buffer amplifier is a very simple, but very interesting little circuit. The two resistors connected to its base create a bias of a bit over 5 volts which is reflected as an output of about 5 volts at the emitter of the transistor. It is beyond the scope of this write-up to explain why such a voltage is created at the emitter of an NPN transistor, but it is and what is more, this voltage point can pass quite a bit of current.

Perhaps I should have qualified my earlier statement by saying that a STATIC 5 volts is produced at the emitter of the VFO buffer transistor because the VFO's output voltage is superimposed on the base's bias voltage and causes the 5 volts at the emitter to "swing" depending on how much voltage the VFO puts out. Of course, the rate of swing is determined by the carrier frequency. For example, if the VFO is putting out a carrier signal of 2 volts peak to peak and at a 1 MHz rate, then the voltage at the emitter will swing between 4 volts and 6 volts at this 1 MHz rate. Since the emitter is tied to a common bus, this bus's voltage swings too, but I'll say more about this later -- just keep that thought for now.

Immediately to the right is the RF output transistor. This stage is equally simple and equally clever. This transistor's base is biased exactly the same way as the buffer's base, to produce a fixed voltage around 5 volts at its emitter. Please note that the base is bypassed by a 0.1 MFD capacitor to ground, so this emitter voltage is fixed and never 'swings' as does the emitter to its left. So here we have two transistors biased to the same

voltage and connected to a common bus, but one 'swings' and one doesn't. Before I go on, please note that the collector of the RF output transistor is connected to a tap on the output coil so that any change in the current flowing through that transistor it will cause the same change in current flow the lower part of the coil. Through the principle of self inductance, this change in current flow will cause a change in the magnetic field of the entire coil and will be reflected as a high voltage signal appearing at the top of the coil. Since the top of this coil is connected to a tuning capacitor, the capacitor and the coil form a tuned (or resonant) "tank" circuit where radio frequency energy is stored.

Finally, there is the modulation transistor below the other two NPN transistors. Note that its collector is tied to the bus that connects the upper two transistor's emitters. With about 5 volts on its collector (from the bus), this transistor is biased so that about 2 volts appears at its emitter. The 100 ohm resistor connected from the emitter to ground means that a static current of about 2V/100R or 20 milliamps flows in this circuit. Remember, this is the static value, because it varies depending on the amount of audio that is present. For example, if the audio level is 4 volts peak to peak, then the voltage at the emitter will vary from 4 volts to zero volts resulting in a current change from 40 milliamps to zero milliamps. The rate of change of this current is the same as the frequency of the audio that is fed to the base of the modulation transistor. For example, if a musical tone of 4 volts peak to peak (we mentioned earlier) and at a frequency of 1,000 cycles/second (or Hz) is present, the current will vary from 40 to zero milliamps at a 1,000 Hz rate. Of course, Mr. Kirkoff's laws state that any current or change in current in the emitter circuit will be reflected in the collector circuit too and since the collector of this transistor is tied directly to the emitters of the other two transistors, the current flowing through them is likewise affected.

The really clever part of this whole arrangement is how the burden of the current flow just described is shifted between the top two transistors. When the left transistor is putting out more than the nominal 5 volts at the emitter (during the positive swing of the carrier wave), all the current flows through that transistor and none through the transistor on its right and thus no collector current flows in the tapped coil above it. When the left transistor is putting out less than the nominal 5 volts (during the negative swing of the carrier wave), none of the current flows in the left transistor, but all of it flows in the right transistor and thus through the tapped part of the coil above it. In other words, every cycle of the wave from the VFO results in a half wave pulse of current being added to the "tank" current flowing in the output coil at the top left of the diagram.

Of course, this current is modified (or 'modulated') by the varying current flowing in the modulation transistor below the other two transistors. Imagine that we have current flow that varies at an audio rate and that this varying current is bused to the two other transistors' emitters. Since the collector of one of those transistors (the RF amplifier) is connected to the tap of the output tank coil, changes in current flow are reflected there and thus we have radio frequency -- Amplitude Modulated -- current flowing in the output coil of this little transmitter. The varying current flowing in the coil reaches a peak voltage and radiation off the antenna stub reaches a maximum as the tuning capacitor (to its right) brings the circuit into resonance.

This is all so clever, but so what? Well, if a stub of an antenna is connected to the top of the tuning coil/capacitor, it will become part of the tuned circuit and its small native capacitance will add to the circuit. Radio frequency voltage will travel down this wire and some of the energy contained in the tank circuit will radiate out to space. Being such a short piece of wire (only 3 meters long), it is only a tiny fraction of the actual wavelength (300 meters) and the radiation resistance is very high, but it looses energy in the form of radio frequency radiation well enough to be heard all over my house.

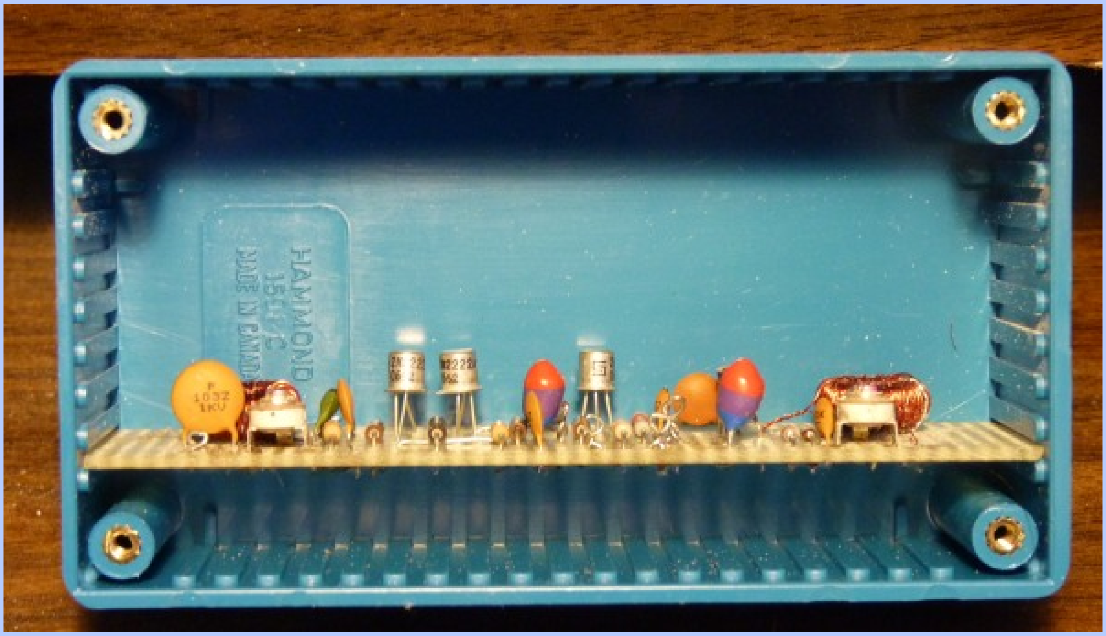
And that folks, is how I think it all works.

There is one other difference between my transmitter and Mr. Wenzel's. To get the input to the modulation transistor up to the required voltage without using an amplifier, I simply put a tiny sub-miniature 8 ohm to 500 ohm output transformer in backwards and I must say that it works marvelously when connected to a speaker output. The modulation is so high that I seriously have to turn down the output until I can barely hear the radio before I connect it to the transmitter's input.

Actually building the transmitter

Now we come to actually building the project. My brain works in a highly "linear" sort of way and so I simply laid out the circuit board from left to right. After I was done, I had a long narrow circuit board that I was afraid wouldn't fit into a standard box very well. I then went down to my local electronics store to look for a nice box to put everything in and, if you can believe it, through the best kind of stupid, unplanned good luck, my board

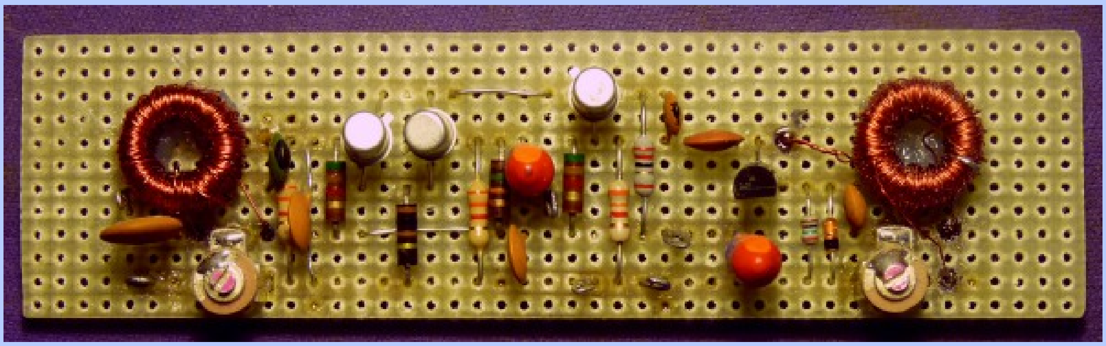
exactly fits a plastic project box that I found there. You see, my board is exactly the right height to fit in the box and it is the exact right length to fit in the slots on the ends of the box so that I didn't have to use any hardware to mount the board. Yes, all I had to do was slide it into one of the slots and screw the lid down. What do you think the chances are of that happening just by dumb luck?? One in a gazillion, I'm sure. In fact, I'm glad I didn't try to measure the board first because I'm sure I would have been off by a hole or two. Wow, I think I'm going to go out and buy a lottery ticket. No need to spend a lot of money, one ticket will be all I need.



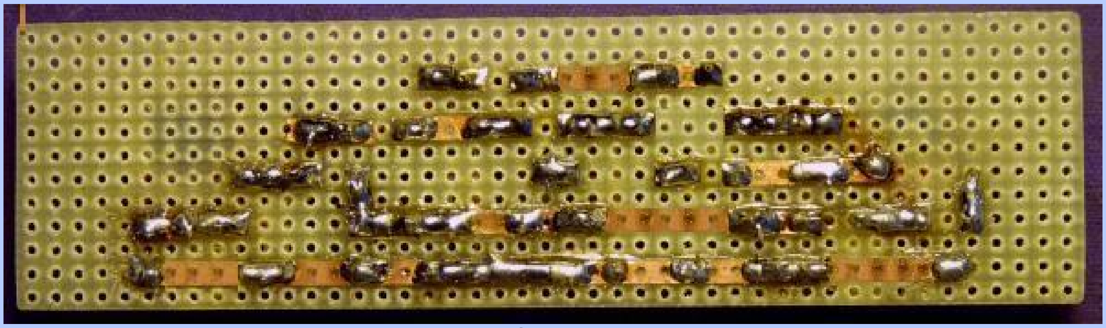
The circuit board fits in the slots of the box just perfectly without having to mount the board with screws or standoffs or anything like that.

Please note that this is an early, unfinished view of the project and does not show the RCA jack (for the antenna and ground), the on/off switch, the audio input jacks, all the interconnecting wires or where I glued the little matching transformer to the bottom of the box with a drop of RTV adhesive. Where you locate all that stuff is up to you to decide and will be based on what kind of box or chassis you choose. By the way, that big red and purple 27 MFD cap in the middle of the board has been replaced with a 0.1 MFD disk ceramic cap for better audio matching.

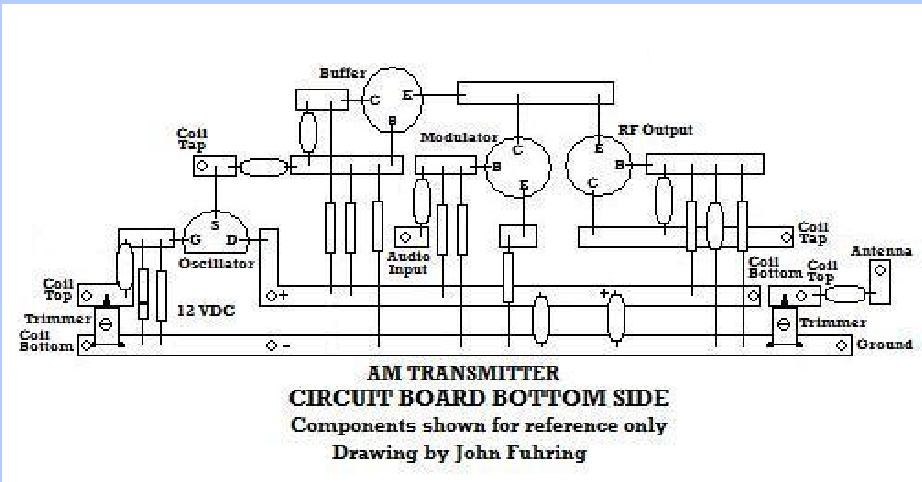
Mr. Wenzel's design calls out for a pot core output coil. While using a pot core would have greatly simplified the winding of the coils, I decided to use readily available T50-1 toroid cores. Yes, winding 20 turns until I got to the tap and 125 more turns (8.5 feet altogether) of number 30 wire onto these little cores was a real annoyance (actually it was a P.I.T.B.) and took a lot of time to do, but those little toroids work great and at least they are cheap and easy to get. By the way, if I would have had them handy, T50-15 cores would have been better because I wouldn't have had to put quite so many turns on the forms.



The Hartley oscillator coil and its associated tuning capacitor and transistor is on the right
the output coil and capacitor is on the left. The NPN on the right is the VFO buffer,
the transistor in the middle is the modulator and the transistor on the left is the RF amplifier.
The three transistors (two emitters and one collector) are connected together by a long bus strip.



These stick-on circuit strips are so much faster and easier than trying to create a printed circuit, especially for a one-of-a-kind project. They are sure a lot prettier than the dreaded "dead bug" method of creating a circuit board.



A sketch like this really helped me to locate the parts on the board.

Not all the resistors and capacitors ended up where shown because better layout occurred to me as I was actually building the board. You might notice that I do not show the 8 ohm to 500 ohm transformer on this circuit board. I mounted the little transformer externally by gluing it upside down and then running the leads to the ground strip and audio input point.

Even more than winding the toroid cores, laying out the components and their associated circuit strips was time consuming. I started out by creating a rough sketch using the Paint program and with it as a guide, I was able to locate all the components on the perf board.

I didn't build the board all at once because I wasn't sure I would be exactly on frequency. After I had the VFO section done, I applied power and connected up my frequency counter. I found I had too many turns on the coil, so I removed about 6 or 7 inches of wire and that brought the frequency up to where I wanted it. I then built the rest of the circuit. To tell the truth, when I went to wind the second coil, I measured out about 8.5 feet of No. 30 wire, counted the first 20 turns to the tap and then just kept on winding until I was out of wire without counting. Things went much smoother on winding the second core.

Connecting to an antenna & ground and tuning for maximum smoke

When I was done, I connected the board's audio input to the output of a portable radio and tuned to an FM station. I connected up a little 12 volt power supply and a 10 foot piece of wire that I strung indoors from the light fixture in my back room, then I turned everything on. It was with a lot of gratification that the transmitter worked and I was receiving the FM station in another portable AM radio. I walked all over the house and I could hear the station everywhere, but the audio was a little muted unless I turned the volume of the transmitter's radio all the way up. This wasn't good, so I put a tiny output transformer in and that worked almost too good as I had to turn down the output to keep from overdriving the transmitter.

For a while I was a little concerned that I wouldn't be able to tune the output of this little transmitter for full

resonance, but then I had an idea. I took my Heathkit CR1 crystal radio, put a little stub of an antenna on it and then tuned down to where my transmitter was. There it was, loud and clear. I then simply tuned the variable capacitor at the transmitter's output until I got a peak signal from my crystal radio and with that, I was in tune.

Mr. Wenzel warned me that I might not get good coverage from this transmitter, but with the transmitter connected to AC ground and an indoor antenna, I can hear the signal all over my house. With a short outside antenna, I found that the signal is even better although not a huge improvement.

Well, now I have a way of broadcasting something worth listening to. Now I can use my restored antique radios once again. It is my opinion that everybody with a restored and working antique radio should have one of these little transmitters so they can bring their old radios back to life.

Here is the latest update. Friday evening, my favorite FM station has a wonderful program on where they play digitally remastered versions of 1920s and 30s music recorded by the great artists of "The Jazz Age." These artists were once wildly popular and household names, but are today (with a few exceptions) completely forgotten. I set up the AM transmitter in my back room and then listened in my living room to its signal using my beautiful 1936 Fairbanks Morse. The music coming out of the old speaker sounded beautiful and the feeling I had was pleasantly strange. The old radio, its old tubes and its speaker was once again playing the music that it had played when it was new and the person(s) listening back then would have heard the very same thing I was hearing. I can't explain it, but it made me feel very strange -- but in a very good way.

Yesterday afternoon and evening I had my 1930s Troy Radio on and listened to my favorite FM station as it was rebroadcast by my transmitter. Part of the programming was old music and again that strange, but pleasant feeling returned. It was kind of wonderful to, from time to time, notice that the excellent sounding audio was coming out of my ancient radio and look at it with its dial and tubes all lit up. To think, the ancient tubes in my ancient radio were passing complex streams of electrons from their hot cathodes to their high voltage anodes and enabling me to hear these sounds. I listened all afternoon and evening and if either the receiver or the transmitter drifted in frequency, it was much too little to possibly notice.

Just recently I've been told about an Internet Radio station called Radio Dismuke. They play the most wonderful music from the "Jazz Age" including the period commercials. It is a wonderful station and I highly recommend piping it into your transmitter so that the tubes in your radio can stream patterns of electron flow just like they did in the 30s. Besides that, you will love listening to what entertained our ancestors as much as they did.

I am so glad I went to the trouble to build Mr. Wenzel's radio transmitter.

A word about parts

You may have noticed that I am not using the same transistors that Mr. Wenzel specified. The fact is, these circuits will work with just about any general purpose NPN transistor. I am absolutely confident that the old 2N170 transistors, the type I used to buy in 1960 for a dollar apiece (about $15 in today's money), would work just fine in these circuits.

In addition to the NPN transistors, you can use any depletion mode, N channel RF FET you want. I used an MPF102 because they are so easily available, cheap and work great. I've already mentioned that the T50-1 toroid cores may be substituted for -15 types and the diameter isn't important either as long as you wind for 280 microheneries and tap somewhere near the ratio I guessed at. With regard to the capacitors, I used cheap, easily available disk ceramics and the electrolytic is an old surplus tantalum slug type I have a ton of, but a modern aluminum type would work just as well.

I guess what I'm trying to say is that none of the parts are in the least bit critical or rare and they may be substituted for quite easily.

There is one thing that a builder might have trouble with and that is the stick-on copper strips. I'm running a bit low on the strips I first got about 20 years ago, so I tried to find the website of the original manufacturer. To my disappointment, I've discovered that they are no longer in business and it seems that nobody makes those strips anymore. So, how would I build such a project if the strips can't be had? Well, when I was looking around for substitutes, I discovered these neat perfboards that have a small island of copper around each hole. To make the equivalent of my strips, all one would have to do is bridge the holes with a tiny drop of solder and

TA-DA, you have your strip.

Some words of encouragement for those hesitating to build something like this

To many people, building something like this project might seem like a daunting task. I assure you that once you get started, the work goes very quickly and it gets fun as it picks up, but the key is to get started. I would suggest that you first try this simple and easy experiment to see where it might lead you.

First, go and buy a perfboard with the plated holes as described above. Take it home and with a small soldering iron and some good electronics grade solder, make up the strips as I have shown, but with solder bridges between holes. Don't worry about getting it perfect because you can always remove solder bridges or add additional ones later if your layout isn't perfect.

Look over your board and try to imagine where all the parts would go. You will quickly see that it is no big deal putting the parts in their respective holes, so then go out and buy (or, if your like me, scrounge) the parts. When you have all or most of the parts, start stuffing the board, soldering the parts in and remove the excess leads with your cutters. It's just that simple and when you have the board stuffed and soldered up, you will be eager to start the tedious part and that's winding the coils.

Use one of the on-line calculators to determine the number of turns you will need and then add a few. To make the tap, simply put on 20 turns or so, twist the wire so you have a pigtail about an inch long and then resume winding. Yes, you will have to be careful the wire doesn't tangle and you will have to straighten out the inevitable tangles, but it only takes a few minutes to wind the coil and you will be so proud of yourself when you are done. The second coil is identical and will be even easier to wind.

Finish your board by soldering in the coils, use your own inventiveness to mount the tuning capacitors. I choose 0-100 pF caps because of their size, but if you can get larger ones or even external tuning caps that you can mount on a panel, that would be even better because it will give you a greater tuning range. You might want to just "tack solder" in the tops of the two coils because you will be taking turns off of them a bit later.

It is your choice to mount the little matching transformer either on the circuit board or (as I did) mount it externally and run its leads to the board. Mounting it externally with a drop of RTV and then running the 8 ohm input leads to the phone jack and the 500 ohm output leads to the audio input and ground of the board is really easy and convenient.

Finally, apply 9-12 VDC and listen for your radios carrier with a AM radio. Even with the VFO's trimmer down to zero, you may be too low in frequency, so unsolder the top and remove turns from the VFO coil until you are within the tuning range you want. Yes, this is tedious and will take you some time. When the VFO's coil is set right, take the same or maybe a few more turns off the antenna circuit's coil, connect the antenna you plan to use and peak the output with your antenna trimmer capacitor. In the text I tell how I used a little crystal radio to do that, but you can do the same thing using a portable AM radio located dozens of yards away. Perhaps you can turn up the volume and listen for it or have somebody tell you when it reaches its maximum loudness. Anyway, you will figure it out.

Harmonics

Does this little radio put out a clean signal? In a word, no. For several technical reasons, the output of this little transmitter is loaded with harmonics and you can hear them at very regular intervals up into the shortwave bands. When I first built this set I didn't have an on/off switch and it was on all the time. When listening for shortwave stations, I'd hear these faint but steady signals and wonder why these stations never faded out. Finally it dawned on me that I was hearing my transmitter's harmonics. To eliminate these false signals on shortwave, I installed an on/off switch and I suggest you put one in too, especially if you want to listen to a part of the radio spectrum that might be affected by harmonics.

So, are the harmonics a problem otherwise? Again, the word is, no. These transmitters require no license even for the fundamental carrier frequency and the faint harmonics can't radiate beyond the borders of your property to cause anybody interference. The only time they cause me any problem is when I'm listening to shortwave and I don't want to be confused by these faint, but readable signals while I'm hunting for foreign stations, so I simply turn off the transmitter when it is not in use.

Last minute change

Lately I noticed that when listening to the output of my little transmitter using a cheap transistor radio (with poor treble control), the audio seemed to have way too much bass on it and it sounded distorted. In fact, it sounded horrible. I had never noticed this before with my other radios, but when I listened carefully using a good receiver, yes there was too much bass.

I simply changed value of the capacitor that couples the output of the audo transformer to the base of the modulation transistor. I had originally put in a 30 mfd electrolytic thinking that I'd make the audio response really flat by having such a huge cap in there. Well, obviously that wasn't working very well so I changed the capacitor all the way down to 0.1 mfd with plans to gradually increase the value until the received audio sounded right. To my surprise, the 0.1 mfd cap sounded perfect and even the lower frequencies sounded about where they should be. I modified the schematic drawing to show this new value and am now suggesting you use a lower value of capacitance to couple the audio transformer to the modulation transistor. You might want to experiment around to see exactly what value of coupling sounds good to you. By the way, this change also eliminated even the small amount of AC hum that had accompanied the carrier.

Well, that's it. I hope you enjoyed the story.

The End

Having arrived this far, obviously you have a superior attention span and reading ability that far exceeds that of the majority of web users. I highly value the opinion of people such as yourself, so I ask you to **briefly** tell me:

Did you enjoy this article or were you disappointed?

Please visit my guest book and tell me before you leave my website.

If you have any detailed comments, questions, complaints or suggestions, I would be grateful if you would please

E-mail me directly

I have posted many articles about crystal radio projects, a couple of regenerative radio projects, a homebrewed ham radio.
In addition, I've posted articles about the beautiful and interesting antique radios that I built this transmitter for.
Please take a second and see if there isn't something you might like to read about on

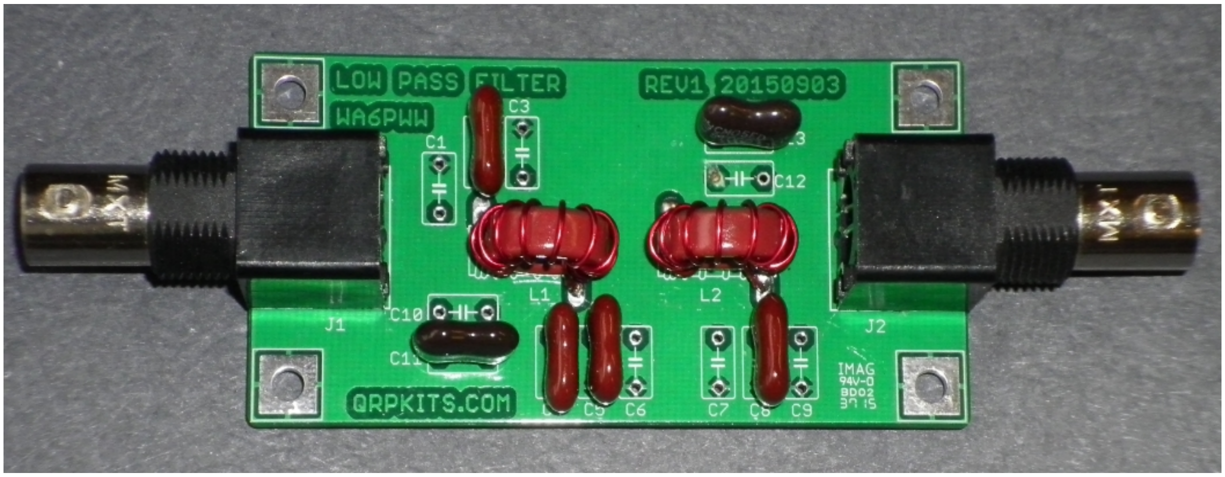
My radio selection page

You will also find some other early radio essays there too.

or, as a last resort, you can

Return to my Home Page and look for something else

Pacific Antenna Low Pass Filter Kit



Description

Many basic transmitter and/or transceiver designs have minimal filtering on their output and frequently have significant harmonic content in their signals.

Our Low Pass Filter kit from Pacific Antenna is 5 pole LC filter designed to reduce harmonics and spurious signals.

Our Low Pass Filter includes capacitors in parallel with inductors that resonate them on the second and third multiple of the design frequency thus further attenuating harmonic energy.

When properly configured, our low pass filter is capable of significantly reducing harmonics of a transmitter, amplifier or any other signal source with minimal effect on the desired signal.

Ideal for reducing band to band interference for field day and contest stations.

This is a relatively simple kit to build and is ideal for beginners.

Specifications

Versions available for 80, 40, 30 and 20 Meter bands

Power handling up to 100W under matched conditions

Reduction of harmonics by more than 50dB

Constructed on a 1.75x 3.5 inch printed circuit board

Designed to be placed inline between a transmitter and antenna

Includes board mounted BNC connectors and all necessary parts

Support

PACIFIC ANTENNA
QRP KITS.COM
qrpkits.com@gmail.com

Recommended Tools

- Temperature Controlled Soldering Station with small tip or 15-35 watt soldering iron with small tip.
- Solder 60/40 or 63/37 Tin-Lead
- Small Diagonal Cutters
- Small Needle Nose Pliers
- Pencil, Pen, and/or Highlighter
- BRIGHT work light

Optional Tools

- Magnifying headpiece or lighted magnifying glass.
- Multi-meter
- Solder Sucker or Solder Wick
- Small multi-blade Screw Driver
- Knife or Wire Stripper
- Small Ruler
- Cookie Sheet to build in and keep parts from jumping onto the floor.

Construction Techniques

- Please take time to inventory the parts before starting. Report any shortages to QRPKITS.com (In many cases it may be faster and cheaper to pull a replacement from your parts supply, but please let us know if we missed something.)
- Pre-sorting the resistors and capacitors can speed up the assembly and reduce mistakes.
- There is no need to print out the whole assembly manual unless you want a copy. Print the Parts List and Schematic (last two pages) then view the rest of the manual on a computer, laptop, or tablet. The Parts List has columns for inventory and construction.
- You can insert several parts at a time onto the board. When you insert a part bend the leads over slightly to hold the part in place, then solder all at the same time. Clip the leads flush.
- Most parts should be mounted as close to the board as possible. Transistors should be mounted about 1/8" above the board. Solder one lead on ICs or IC sockets and then check to make sure the component is flush before soldering the remaining leads.
- Use a Temperature Controlled Soldering Station with small tip or 15-35 watt soldering iron with small tip. Conical or very small screw driver tips are best.
- DO NOT use a large soldering iron or soldering gun.
- If you are a beginner, new to soldering, there are a number of resources on the web to help you get on the right track soldering like a pro. Google Soldering Techniques. Here is one good example:

http://www.elecraft.com/TechNotes/N0SS_SolderNotes/N0SS_SolderNotesV6.pdf

Printing the Manual

Note: There is no need to print out the whole assembly manual unless you want a copy. Print the Parts List and Schematic then view the rest of the manual on a computer, laptop, or tablet. The Parts List has columns for inventory and construction.

Inventory and Parts List

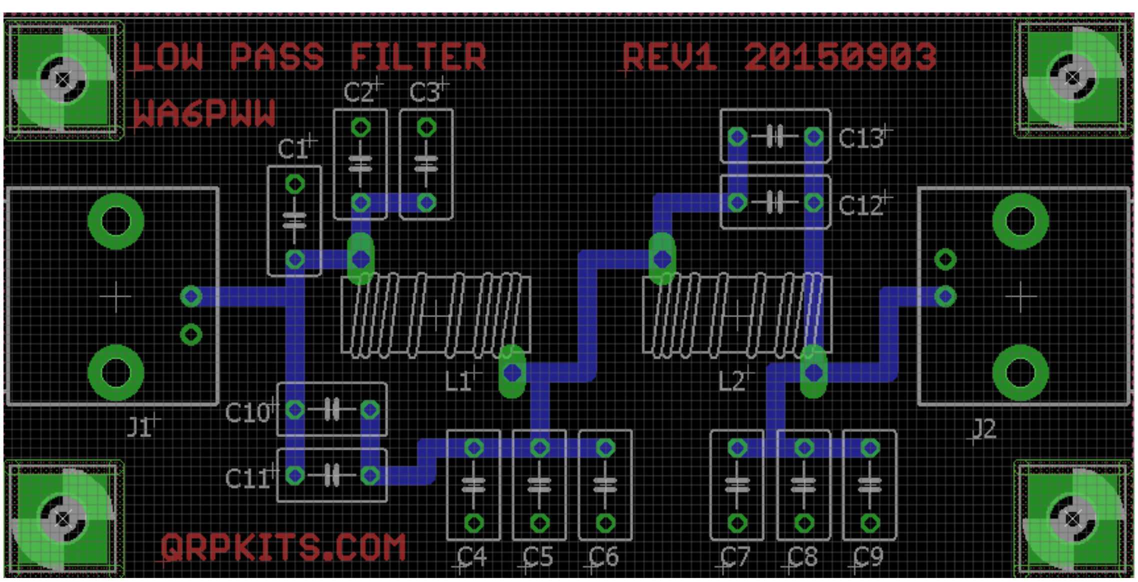
Please take time to carefully unpack and inventory the parts in the kit before starting.

In the unlikely event there are missing parts, contact QRPKITS.com for replacements.

Use the first column of the table below to check the parts as you inventory them and use the second column to check the parts as you install them.

Parts

Inven.	Installed	Part #	10M +12M	15M +17M	20M	30M	40M	80M*	160M
		PCB	1	1	1	1	1	1	1
		BNC J1, J2	2	2	2	2	2	2	2
		C1, C2 or C3	TBD	TBD	150pF	180pF	270pF	1000pF	TBD
		C7, C8 or C9			150pF	180pF	270pF	1000pF	
		C4, C5 or C6			300pf or 2x 150pF	360pF or 2x 180pF*	560pF	1800pF*	
		C10			22pF	27pF	22pF	100pF	
		C11			N/A	N/A	22pF	N/A	
		C12			51pf	33pF	51pF	270pF	
		C13			N/A	33pF	51pF	N/A	
		L1	T50-6	T50-6	11 turns T50-2	14 turns T50-2	16 turns T50-2	21 turns T50-2	T50-2
		L2	T50-6	T50-6	11 turns T50-2	14 turns T50-2	16 turns T50-2	19 turns T50-2	T50-2
		#22 Wire			2ft	2.5ft	3ft	5ft	



Inserting the Parts

Install the components listed in the table for the band chosen as indicated below. The parts layout on the previous page shows the locations.

Install BNC connectors

Note: If you plan to mount this kit in a case or build into another assembly where input and output connectors will not be needed or mounted on the case you may not want to install the on board BNCs.

Solder the supplied BNC connectors on each end of the board in the positions marked J1 and J2. Be sure that the connectors are fully seated and then solder the support pins one at a time.

After the first support pin is soldered, recheck that the connector is seated on the board. If not, reheat the connector support pin while pressing down on the board to fully seat it. Once the connectors are seated and both support pins are soldered, go ahead and solder the two signal connection pins (smaller) on each BNC.

Wind and Install Toroids for L1 and L2

Wind the toroids to create inductors L1 and L2 to the specified number of turns specified in the parts list.

Remember that each pass through the center of the toroid counts as 1 turn.

Spread the turns uniformly around the toroid, leaving space for the ends of the winding to align with the circuit board holes.

The wire supplied is heat strippable and you can tin the ends of the wires using either the solder blob technique or by first sanding or scraping the insulation from the wires to expose the bare copper and then tinning with solder.

Install L1 and L2 in the circuit board holes and pull the wires gently to remove slack and hold the toroids close to the board.

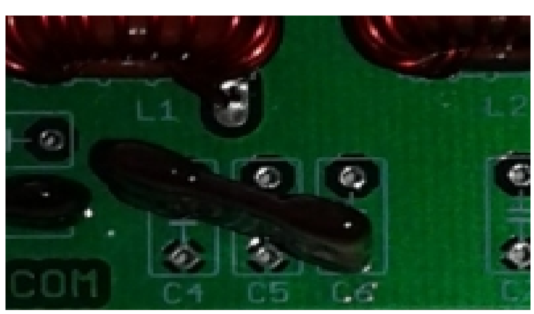
Solder L1 and L2 in place.

Capacitors

Note: not all positions will always be filled with capacitors. The additional capacitor locations are there so that multiple capacitors may be paralleled to give the needed value for a particular frequency of operation.

Install the appropriate value capacitors in positions C1 through C13 as indicated in the table for the version you are building.

***Note:** For the 80M version, due to its size, the 1800pF cap should be installed diagonally across from the upper pad of C4 to the lower pad of C6 as shown here:



Checkout:
Inspect the board for any bad solder joints, shorts or other problems and correct before use.

Using a multimeter in resistance mode, measure the resistance between the center pins of input and output BNC connectors (or pads on the board if BNCs are not installed). The value should be low, usually less than 1 ohm and confirms that the components are in place and leads connected.

Check from the BNC center to shell (or across the input or output pads if BNCs not installed). There should be a very high resistance, probably infinite reading on the DMM resistance scale. This confirms that there are no shorts to ground.

Congratulations, you have now completed the assembly of your low pass filter kit!

Packaging

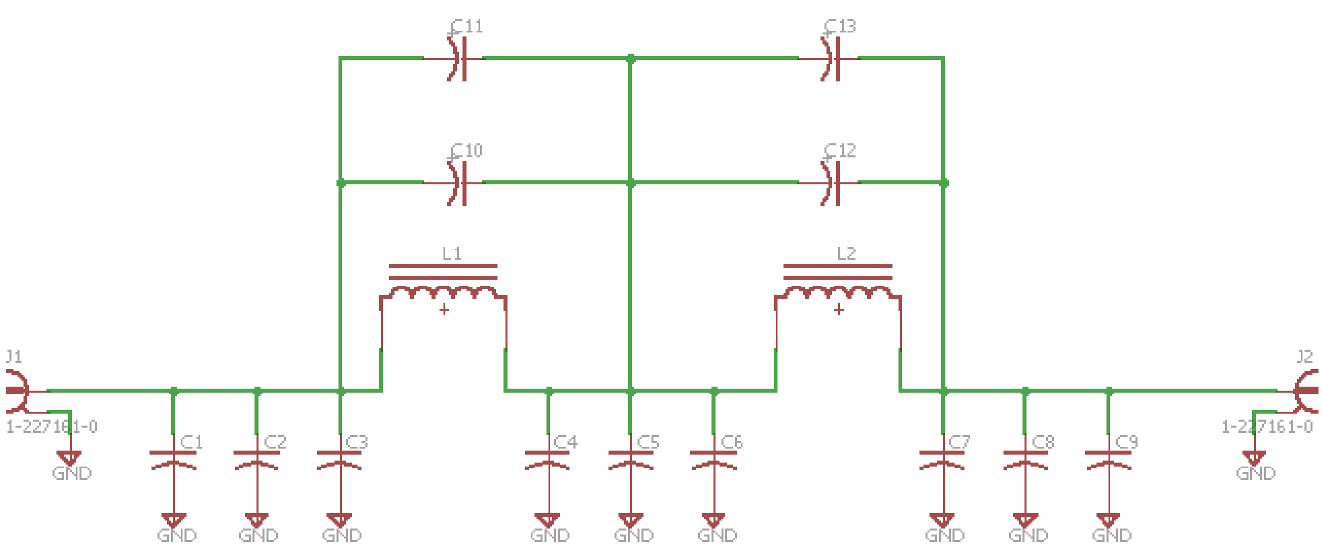
Packaging is left up to the builder. The kit can be used inline as is, built into another assembly or installed in a case.

Usage
The low pass filter is placed in the coax line following a transmitter, transceiver or other signal source. It has minimal attenuation of signals below the designed cutoff frequency and will provide high attenuation above the design frequency with notches at the second and third harmonics to provide additional attenuation.

Adding a low pass filter tuned to the band of operation will clean up a transmitter or amplifier that has little or poor filtering or which can benefit from increased attenuation of signals above its operating frequency.

This can be very helpful for reducing interference between nearby stations on different bands such as during field day or contests.   For example, using the 40M LP filter on a 40M station will reduce harmonic energy and reduce its interference to other nearby stations operating on higher bands such as 20M.

Schematic Diagram



[DIY Audio Home]

ECC99 SRPP Headphone Amp

This little guy is a headphone amplifier that I designed mainly to drive the fine AKG K1000 headphones. K1000's are hard to drive, as headphones go. Their impedance is pretty typical of headphones, at 120 ohms... but they require a lot of voltage (power) to get to a good listening level. They're rated at 1 watt maximum, which corresponds to 11V RMS, and at their stated efficiency of 74dB/mW, you need 400mW of drive to get to 100dB, which is a good target for a maximum listening level. This amp will drive 325mW, which gives about 99dB... plenty loud for me.

My OTL tube amps can get close to this power level, but the problem is that the K1000's don't sound very good unless they're driven with a really low output impedance. They were designed to be driven by a "normal" power amplifier, with a Zo of only a few ohms. When you drive them with an amp that has, say, 30-50 ohms Zo, they sound very thin (especially in the bass).

So, I designed an amp to drive them.

This amp is unlike my other headphone amps in that it is NOT an OTL design. It uses an SRPP output stage, driving a special parallel-feed headphone output transformer made by Sowter in the UK. I bought transformers directly from Sowter in the UK, paid with a credit card, and got my transformers within 10-14 days in the US.

I used the current-production JJ Electronic ECC99 dual triode tube, which is an excellent audio tube. You can buy the ECC99 from Triode Electronics for around $14.00 each.

The transformer has three secondary windings which you can connect to get different output impedances. I put in a switch to let me select the middle (two windings in series) and highest (three in series) combinations. The Zo of the SRPP stage is so low that at the middle setting, the amplifier Zo is something like 7 ohms, which is great for the K1000's. On the higher setting there's more than enough voltage to drive even 600 ohm headphones.

An SRPP amplifier uses two tubes wired in series - the lower tube's grid is driven, and it works like a normal grounded-cathode amplifier. The upper tube does two things; it acts like a constant-current source, which provides a constant plate current to the lower tube, hence a very high AC impedance, and a near-horizontal load line. When the load is taken from the cathode of the upper tube, it also acts as a cathode follower, providing a very low source impedance.

Here's the schematic (SRPP amp, for K-1000 and other headphones) (47k PDF file)

If you are using this amp to drive something other than the K-1000's (which require a very low drive impedance), you might want to consider an alternate connection of the output - a current-sourced grounded-cathode amplifier. Taking the output from the plate of the lower tube is more like a "pure" triode amplifier, since in this mode the upper triode acts only as a current source, and not as a cathode follower. The output load - as reflected through the transformer - provides a load to the plate of the lower tube (in parallel with the upper tube), so the load line is dominated by the output load. With this connection, the output impedance is set by the Rp of the lower tube. You could even put in a switch to select between the two if you'd like.

Alternate schematic (current-sourced grounded-cathode amp, for "normal" headphones) (38k PDF file)

Parts list (text file)

Link to transformer data sheet (Sowter 8665)

Link to JJ electronic ECC99 tube datasheet

Some Specs

These measurements were made on the prototype, with no output resistance in series with the output, and the output taken from the cathode of the upper tube (SRPP connection):

Maximum output (5% THD) into 100 ohm load	Switch set to Low Z	4.2V RMS (176mW)
Maximum output (5% THD) into 100 ohm load	Switch set to High Z	5.7V RMS (325mW)
Maximum output (5% THD) into 300 ohm load	Switch set to Low Z	4.4V RMS (65mW)
Maximum output (5% THD) into 300 ohm load	Switch set to High Z	6.4V RMS (137mW)

THD at 1V RMS, 1kHz into 100 ohm load	Switch set to Low Z	1.0%
THD at 1V RMS, 1kHz into 100 ohm load	Switch set to High Z	0.8%
THD at 1V RMS, 1kHz into 300 ohm load	Switch set to Low Z	0.9%
THD at 1V RMS, 1kHz into 300 ohm load	Switch set to High Z	0.7%

THD residual is virtually all second harmonic, giving the characteristic "single ended triode" signature

Freq response 20-20kHz -1.0dB/-0.3dB ref 1kHz 1V RMS, either output Z selected... -3dB down at 70kHz

Noise referenced to 1kHz 1V RMS -65dB (probably near my measurement limit)

More Pictures (by popular demand?)

Front view

The knob on the left is the volume control, and the one on the right is the impedance selector switch. A standard 1/4" headphone jack is next to the XLR connector, which connects directly to the K-1000's without using the extension cable.

Rear View

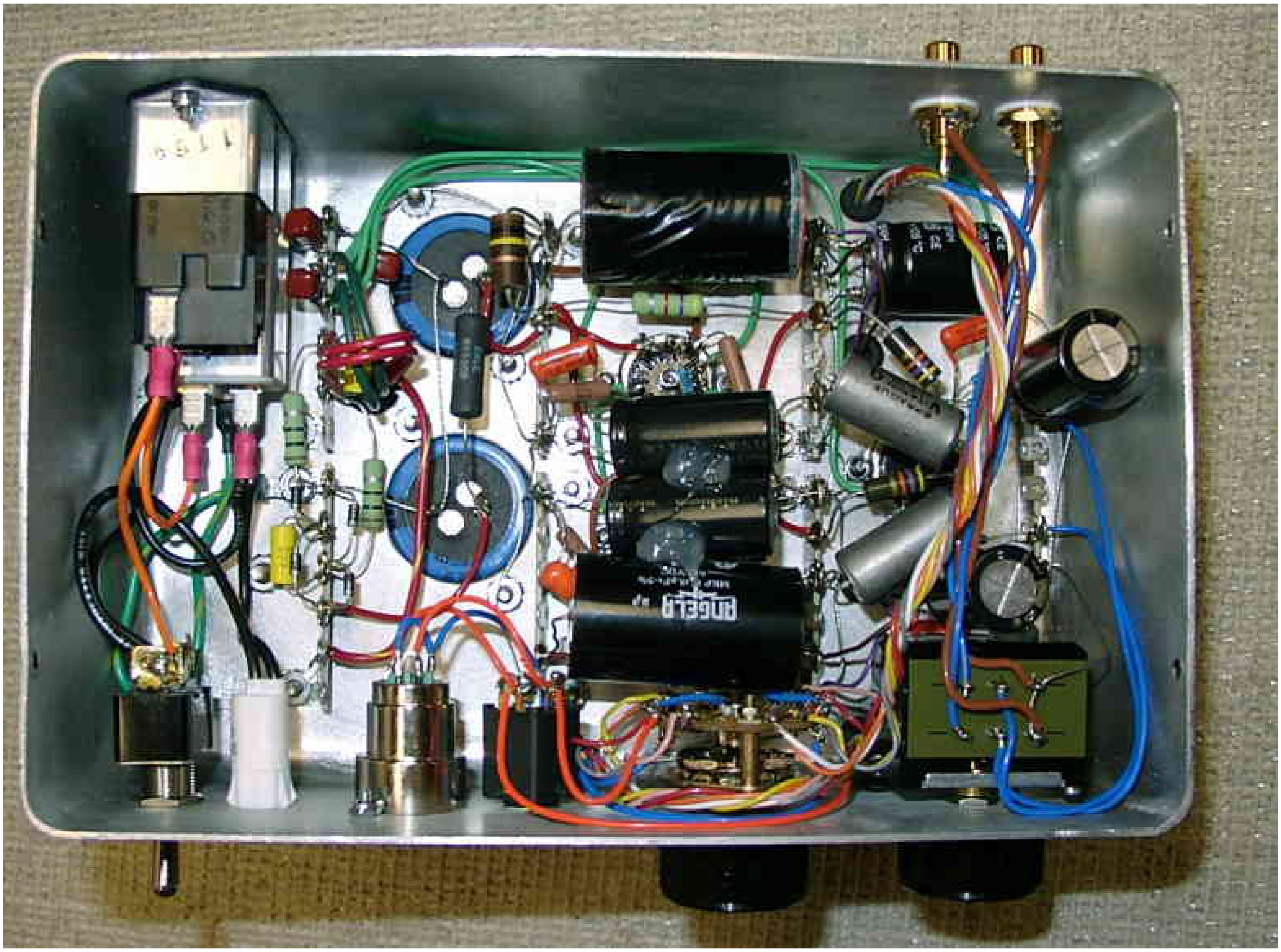
Just a filtered, fused power inlet and the input RCA jacks (isolated from the chassis).

Top View

The 12AU7 is to the left, and the two ECC99's to the right.

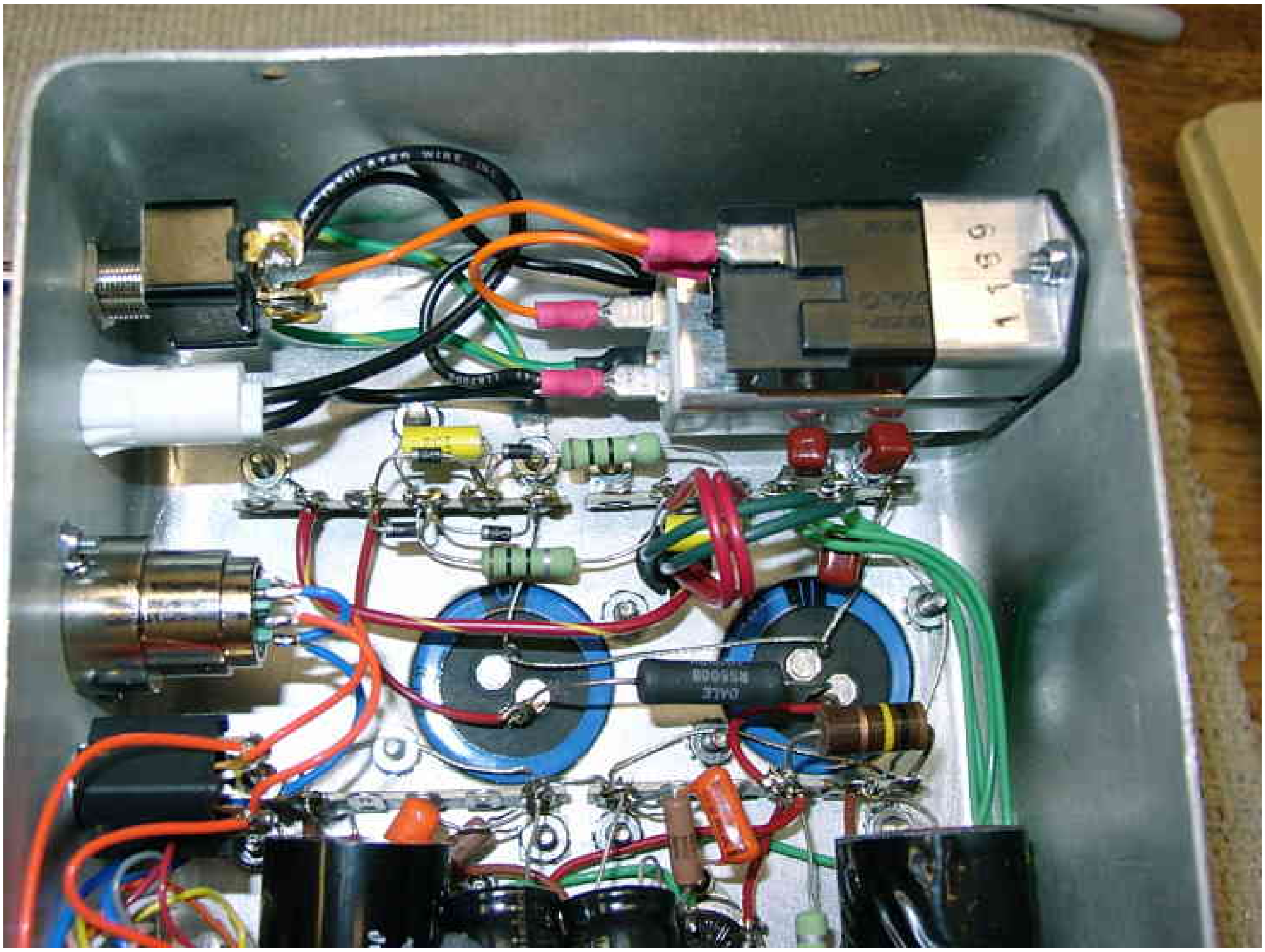
Inside Chassis

Pretty crowded inside here. The large black capacitors are the output caps (10uF), and between them are the cathode bypass caps for the output (also paralleled by some smaller orange drop caps). The metal-cased caps are "Vitamin-Q" paper in oil caps coupling between first and second stages. Cathode bypass caps for the input stage are at the far right. All the transformer output wires run to the rotary switch, which selects the impedance. The green wires running around are the AC tube filament supply.



Inside chassis (power supply side)

Here you can see the AC wiring, as well as the power supply. The two terminal strips contain the filter (some call them snubber) parts on the transformer secondaries, as well as the rectifier diodes. Below that is the C-R-C filter for the B+. The 100K 2W resistor is a bleeder. You can just see the cathode resistors for the output stages, paralleled with the orange drop caps (and the electrolytics at the very bottom edge).



Inside chassis (input side)

Another view of the input side. The little can electrolytic at the top left is a B+ filter for the input stage, connected to B+ through the 4.7K 1W resistor you can see. An ALPS 29mm volume control is at the far right. The 47K 1W resistors are the plate loads for the first stage. You can see one of the plate resistors, and a little blue resistor that connects to the grid of the upper tube, for one of the output stages. The rest are hidden under the capacitors.

Some construction hints

As you can see from these pictures, the inside of this chassis (which is 6" x 9" x 3") is really crowded. I used this chassis (which is a deep-drawn aluminum box) because I had it - I would advise using a larger chassis, maybe 9" x 12", or even larger. If you use a bigger chassis you can separate the power supply (especially the transformer) from the other parts, and don't have to worry so much about laying out the parts so that everything fits. Especially if you are inexperienced in point-to-point wiring, it's a lot easier if you have room to spread things out and get the soldering iron in there without melting anything.

Even crammed together like this, the amp is VERY quiet. No audible hum or noise.

CRYSTAL SETS 1

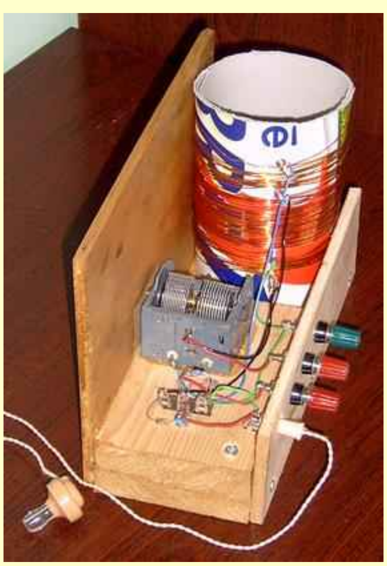
Introduction

What - Why - How

Home | Contact | Site Map | Radio Stations & Memorabilia | Amateur Radio

Crystal Sets & other pages:

An old fashioned style detector that is housed in a glass tube. The point of the cat's whisker touches the crystal (galena) on the left & is adjusted with the black handle.



CRYSTAL SETS PART 1 - INTRODUCTION

What They Are, Why They Came Into Being and How YOU Can Build Your Own CRYSTAL SET!

What are Crystal Sets? I am glad you asked! It is a fascinating subject dating back to 1920 when Marconi first started experimenting with radio broadcasting from his station 2MT in Chelmsford.

The earliest listeners to Marconi's experimental radio programmes would have mainly used the most basic of radio sets called a Crystal Set. Companies such as the W.G Pye began producing early radio sets in 1921 which used electronic components called 'valves', the forerunner to today's transistors and silicon chips). These glass valves could be arranged to amplify the weak radio signal to make them louder - enough to operate a loudspeaker. However these radios were expensive and needed electricity or bulky lead acid batteries to operate.

THE MAGIC OF A CRYSTAL SET

The crystal set was popular during the 1920's and 30's because it was cheap to buy, much cheaper if you built one yourself, perhaps only a few shillings. Additionally a Crystal Set did not require electricity or expensive batteries, however it could only provide enough volume for headphone listening, and if it was situated in an area of low signal strength the listener would also require a very quiet room as the volume would be low. However In the 1920's hearing voices and music from a station miles away with no wires (hence the term Wireless) really was a magical experience! Listeners in the early twenties were also tinkerers and experimenters, trying different designs of crystal set in an attempt to get the loudest and clearest reception.

Since crystal sets have no batteries and no mains power, they rely entirely from the electrical energy developed between the aerial an earth connections - producing sounds as if by magic.

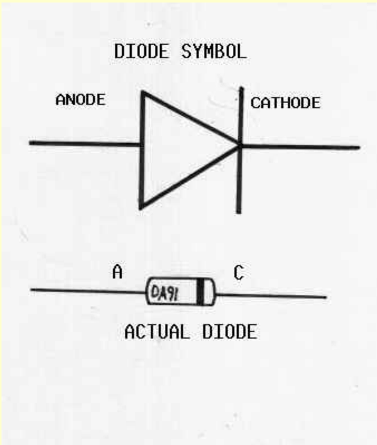
The crystal set had to be carefully tuned into the station by making adjustments to a tuning coil and condenser, these early crystal sets had the added complication of using a 'Cats Whisker' as the detector. The detector converted the radio waves received from the radio station into an audio wave that could be heard in the headphones. The Cats Whisker was a fine wire that rested onto a piece of galena, the crystal, and had to be very finely adjusted to obtain the loudest and clearest sound. Once the 'sweet spot' was found it was important not to move it, it would be very frustrating if someone bumped into the table and dislodged it!

To work at all a crystal set requires a very large aerial, but this is nothing more than a long piece of wire, perhaps 20 to 50 yards of insulated copper wire, hung outside around a garden between poles or trees, or even around the loft space. For the aerial to be effective it needs to be balanced with an earth. An earth is simply a copper rod or pipe about one yard long driven into some soft damp earth with a mallet. At the top of the pipe is fitted a jubilee or hose-clip to which is attached a length of insulated copper wire which is then fed into the house, along with the aerial wire, to the room where the crystal set will be operated and connected to the set's terminals.

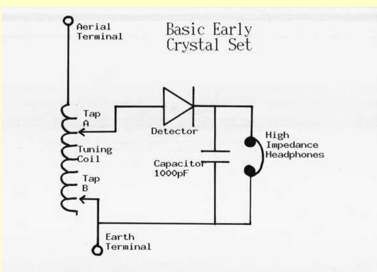
It is quite possible to build your own crystal set. In its very simplest early form a crystal set consisted of a coil of wire, something called a 'detector' and a pair of very special headphones.

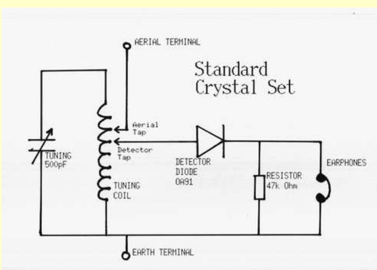
THE CONSTITUENT PARTS

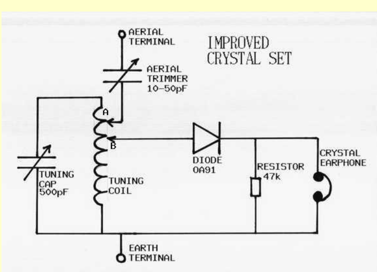
Above: A REAL Crystal Set
You Can Build One Too!
[HERE](#)



An illustration of a modern diode which is often encapsulated in glass and is about 7mm long. Above is the electronic symbol for a diode.







The coil of wire is called a Tuning Coil, and the number of turns of wire on the coil determines the wavelength (frequency) that the set is tuned into. Tuning to different stations can be accomplished by varying the number of turms on the coil, or more easily by having many different tapping points on the coil so that adjustments can be made.

To make tuning easier a component called a tuning capacitor can be included in the circuit. In very early sets a tuning capacitor was not always included to keep costs down, or due to their being difficult to obtain.

The Detector converts the radio wave received into an electrical wave that is suitable for the headphones to, in turn, convert into sound waves that can be heard by the human ear. In the very early days of the crystal set the detector consisted of a holder containing a piece of galena crystal that had a very thin and springy wire placed on its surface that had to be very delicately adjusted to find the sweet spot where the radio station could be heard. This was commonly referred to as a "Cat's Whisker". Modern detectors are called diodes and are more efficient than early detectors and cats whiskers. Diodes are still quite readily available and inexpensive. Part numbers for modern diodes include OA90, OA91 and IN34. Diode part numbers that are perhaps now more difficult to obtain include OA47 and OA81.

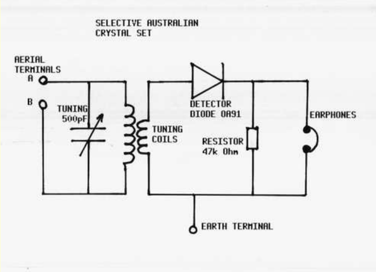
The headphones have to be of a very special type called high impedance headphones. Because there is no additional power source in a crystal set the current generated in the circuit is tiny - minuscule in fact. Ordinary low impedance headphones, such as Walkman headphones, would present a virtual short circuit to the crystal set allowing the tiny signals to drain away to earth & consequently producing no sound - not very useful!

High impedance headphones, on the other hand, reduce or impede the flow of current down to earth, in effect saving the tiny signals to produce sounds from the headphones that we can then hear.

There is a problem however, these high impedance headphones that were so readily available in the 1920's and 1930's are to so easy to obtain today, but some specialist vintage radio outlets still stock them though the price can be quite high. They can still be seen in museums of course. All is not lost though, today we can obtain a special earphone called, appropriately, a crystal earpiece very easily and far more cheaply than. An electronic component, called a resistor, must be connected accross the crystal earphone to allow a path for DC current to get to earth. The value of the resistor is usually 47,000 Ohms and without it a crystal earphone tends to block DC current and as a consequence the sound will be very quiet and distorted.

Aerial and Earth: For a crystal set work it needs an efficient aerial and earth. Since a crystal radio has no power - no batteries or mains electricity - it relies entirely on the radio wave energy sent out from the radio station's transmitter and collected by the aerial to work. The aerial simply consists of a length of wire, but it necessarily has to be quite long, usually in the order of 10 to 20 meters. For the aerial to be effective the crystal radio set also has to be connected to a good earth point. A good earth often consists of a 3 or 4 foot copper stake driven into the ground, but sometimes a water pipe can be used to reasonable effect. (Safety: Never use the earth pin of a household mains plug)

The circuit diagram (schematic) for a crystal set is shown below. Practical designs are shown on the following [pages](#).



No AM radio stations or transmitters in your locality or country?

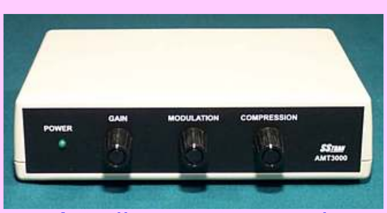
Has your local medium wave broadcast station closed or been moved to VHF/FM or Digital? Don't worry! You can still build and experiment with crystal sets and TRF radios by also building or buying a simple low power AM transmitter. So, not only can you use your crystal sets but you can also run your own radio station that can be heard in and around your home - playing the music or programmes that you want to hear!

Spitfire & Metzo Complete high quality ready built medium wave AM Transmitters from Vintage Components:
http://www.vcomp.co.uk/index.htm

Choice of Spitfire and Metzo transmitters:
Spitfire:
http://www.vcomp.co.uk/spitfire/spitfire.htm

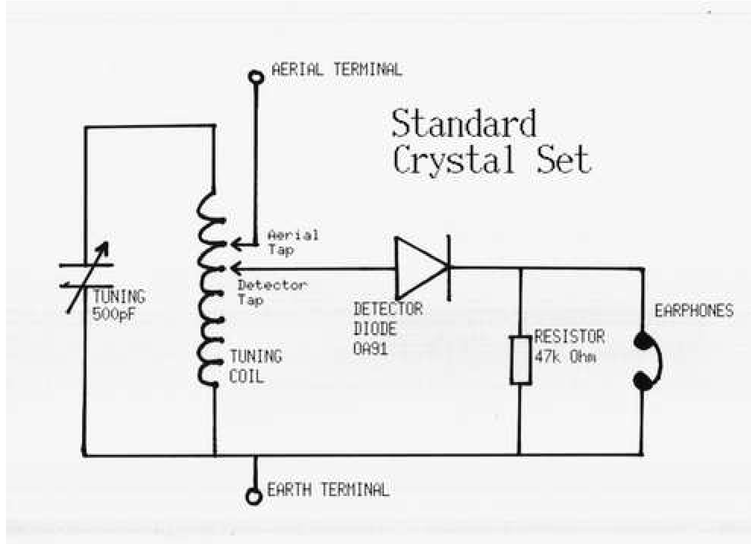
Metzo : AM transmitter including audio compression circuits:
http://www.vcomp.co.uk/metzo/metzo.htm

SSTRAN AMT3000 : Superb high fidelity medium wave AM transmitter kits from SSTRAN. Versions available for 10kHz spacing in the Americas (AMT3000 or AMT3000-SM) and 9kHz spacing in Europe and other areas (AMT3000-9 and AMT3000-9SM). Superb audio quality and a great and well designed little kit to build:
http://www.sstran.com/pages/products.html



http://www.sstran.com/

AM88 LP : AM transmitter kit from North County Radio.
http://www.northcountryradio.com/Kitpages/am88.htm



Above: The circuit diagram for the standard Crystal Radio

Above: A commercially made crystal set from around 1940

There is no variable tuning capacitor (condenser) in the above design. The capacitor is a fixed component and tuning is achieved by varying the coil inductance with the rotating switch. The detector is a galena crystal, seen at the top of the panel. A pair of high impedance magnetic headphones can just be seen to the right of this shot. (photo sent in by our reader Krysatec in Czechoslovakia - thanks!)

EXCELLENT RESULTS

Almost certainly when building a crystal set today a crystal earphone will need to be used. A crystal earphone is not quite as good as the old high impedance headphones as it is not quite as sensitive and therefore not quite so loud, however today's transmitters are much more powerful than those of the 1920's and so really excellent results are very often obtained - just don't expect to hear everything that you might on a top quality portable radio!

Crystal sets are fascinating because they are so simple to build, and because there is no power required they remain magical to this day. I have built several over the years, with differing designs, and if you'd like to build one yourself, it's easy, and I have described some circuits in part 2 with some more experimental ideas in part 5.

I have a crystal set that receives BBC Radio 4 on long wave and 3 local stations and 3 national stations on medium wave and another that also receives shortwave

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- **Amateur Radio by MØMTJ**

stations. Not bad for radios with no battery or other power - and such as set could be very useful in an emergency.

More About Diodes - unconventional and new ideas (by Felix Scerri)

While messing around with diodes for crystal sets recently, I tried something as a theory that actually works very well in practice, and with one or two actual advantages.

Ordinarily the ubiquitous 1N914 or IN4148 silicon switching diodes are pretty hopeless as RF detectors unless RF signals are *very* strong! However there is a simple way of making these diodes work very well as RF detectors, by the addition of adjustable voltage bias. I have used adjustable voltage bias with diodes before with very good results, but using bias with IN914 or 1N4148's is a relatively new idea!

Interestingly enough with voltage bias correctly adjusted, 'weak signal' performance and sound quality is actually very good, with that typically 'crisp' silicon diode 'sound'. I use a simple bias network with a 1.5 v AA battery and a 1 Megohm potentiometer applied to the diode directly with the incoming RF fed into the diode through a 1 uf plastic film capacitor (as shown). The use of adjustable bias seems to help most with 'repositioning' the position of the knee in the diodes curve and weak signal performance is excellent, easily as good as any 'proper' germanium diode.

Another 'tweak' that is actually quite beneficial is 'paralleling' several diodes together. This doesn't work with ordinary germanium diodes but definitely works with BAT46 'germanium equivalent' diodes and the effect of three of these diodes together is to make a better 'single' diode. The turn on voltage is noticeably reduced and the 'square law; region of detection is definitely improved and so is the rectified audio quality. These diodes are relatively inexpensive (at least in this country), so it is worth trying. 73 Felix vk4fuq 080214.

Part 2
Practical Designs To
BUILD YOUR OWN CRYSTAL SET!

Having difficulty in finding components? I have added some ideas for component sources here.
Sources For Older Components

Build Your Own Crystal Set (Part 2) | **Spider's Web Crystal Set (Part 3)**

Crystal Set By Kenneth Rankin (Part 4) | **Experimental Crystal Set (Part 5)**

LINKS

Components:

BOWOOD ELECTRONICS - A friendly, helpful and very speedy source for your electronic components at prices that won't frighten your wallet! - The MK484 IC (the ZN414 replacement) is available from here.

VINTAGE COMPONENTS - A great resource for crystal sets, components, valve radio kits and medium wave AM transmitters!

6V6 - Electronic Nostalgia and Vintage Components

1N34A.com - crystal radio parts, including litz wire is http://1n34a.com

More Links To Electronic Component Suppliers here

Crystal Sets and other interesting radio related topics:

OZ CRYSTAL RADIOS by Austin Hellier

Simple crystal set receivers used by soldiers during the war and by prisoners of war (P.O.W.'s):
THE FOXHOLE and P.O.W RADIOS

Dave Schmarder's Crystal Set Pages
http://www.makearadio.com/crystal/index.php http://www.makearadio.com

"Heart of England Crystal Radio Club" based in Birmingham, West Midlands - http://crystalradioclub.co.uk

Stay Tuned http://www.crystalradio.net/
Designs http://www.crystalradio.net/crystalplans

The Tuggle Two Crystal Set
http://www.crystalradio.net/crystalsets/miketuggle/index.shtml

Jim's Crystal Radio Page http://www.hobbytech.com/crystalradio/crystalradio.htm

VE7SL Crystal Radio DXing http://members.shaw.ca/ve7sl/crystal.html

Gollum's Crystal Receiver World http://www.oldradioworld.de/gollum/

High Fidelity AM/MW Broadcast Band Reception by Felix Scerri
http://sound.westhost.com/articles/am-radio.htm

Crystal Set by G3XBM http://homepage.ntlworld.com/lapthorn/xtal.htm

Experimental Crystal Set Designs by Ken Harthun
http://www.qsl.net/kc4iwt/xtal/SWMystery.htm

Short Wave Crystal Set by Al Klase
http://www.skywaves.ar88.net/SWXS/shortwave.html

Scott's Crystal Radios and links http://oldheadphones.com/crystal/index.html

Crystal Set Analysis by Phil Anderson WØXI (ARRL)
http://www.arrl.org/qex/2008/09/Anderson.pdf

High Sensitivity MOSFET Crystal Set (ARRL)
http://www.arrl.org/qst/2007/01/culter.pdf

MOSFET Crystal Radio by G1EXG http://www.creative-science.org.uk/epadmosfets.html

Peebles Crystal Radios http://www.peeblesoriginals.com/

Crystal Set Kits http://www.peeblesoriginals.com/crystal-kits.html

http://www.peeblesoriginals.com/catalog/45.php

Early Wireless http://www.earlywireless.com/crystal_sets.htm

Stay Tuned Crystal Radio Resources http://www.crystalradio.net/

Birmingham, Alabama Crystal Radio Group http://www.crystalradio.us/index.htm

Borden Radio Company - commercial website (USA)
http://www.xtalman.com/literature.html

Geoff's Crystal Radios - commercial website (UK) http://crystalreceiver.co.uk/

Crystal Radio Supply - commercialwebsite (USA)
http://www.crystalradiosupply.com/index1.html

The Xtal Set Society - commercial websites (USA) http://crystalradio.org/
http://www.midnightscience.com/

Vintage Radio http://www.vintage-radio.com/

PAGES WITH ARTICLES BY RADIO EXPERT FELIX SCERRI:

High Quality AM Receivers:

http://www.crystalradio.net/scerri/index.shtml

http://www.crystalradio.net/

http://www.xtal-sets.com/

Hi Fi AM Receiver Designs:

http://sound.westhost.com/articles/am-radio.htm

TRF Radio Websites:

Gilbert Davey's Radio Sets - A growing resource for all who either remember building radio sets to his designs or would simply like to find out more: http://www.daveysradios.org.uk

Vintage Radio - TRF Radio Designs: http://www.vintageradio.me.uk/radconnav/transtrf/

Vintage Radio - Home Page: http://www.vintageradio.me.uk/

Vintage Radio - Circuit diagrams for crystal sets, TRF and superhet radios, valve and transistor designs: http://www.vintageradio.me.uk/radconnav/radcon.htm

TRF Designs on Birmingham Alabama Crystal Radio Group: http://www.crystalradio.us/1adradios/1ad-2007-2.htm

Regen Radio Tutorial N1TEV : http://www.electronics-tutorials.com/receivers/regen-radio-receiver.htm

Coil Calculations: http://bellsouthpwp2.net/w/u/wuggy/coils.html

E.P.E. Everyday and Practical Electroncs Magazine: http://www.epemag3.com/

The Radio Board Forums - incl Audion Receiver: http://theradioboard.com/rb/viewtopic.php?t=6161&start=30

OTHER ARTICLES

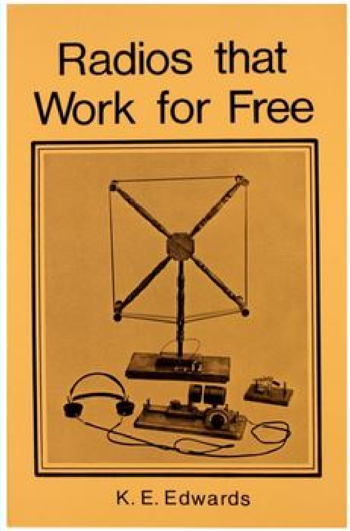
ESP by Rod Elliot - "Mad as Hell" & lead free solder directive:

http://sound.westhost.com/madashell.htm

ESP by Rod Elliot - CFL's (Compact Fluorescent Lamps)

http://sound.westhost.com/articles/incandescent.htm

BOOKS



"Radios that Work for Free" and "Radios that Work for Free II" are now available on Amazon Kindle Books! After 38 years in print "Radios that Work for Free" is now an E Book and K. E. Edwards' new book has just been released as an E Book as well. Crystal set builders worldwide have a new set of crystal set plans and photos to be encouraged and inspired by. These books take the reader from beginner to a competent builder of crystal sets. Take a look inside on Amazon Kindle books.
Hope And Allen Publishing - www.hopeandallen.com

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^Top Of Page

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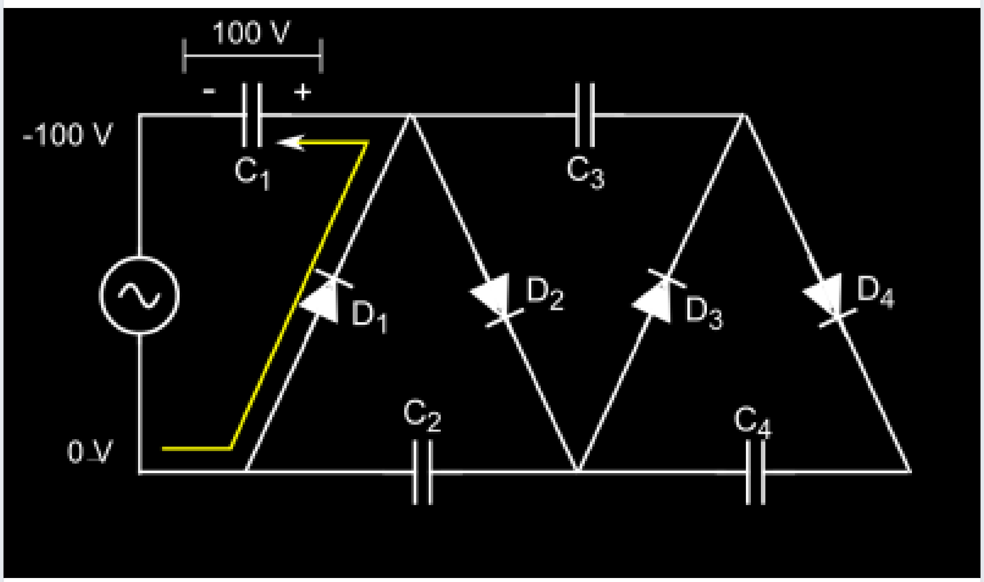
HOW DOES A VOLTAGE MULTIPLIER WORK?

Posted by | Mar 22, 2017 | Hacker News | 0 |



If you need a high voltage, a voltage multiplier is one of the easiest ways to obtain it. A voltage multiplier is a specialized type of rectifier circuit that converts an AC voltage to a higher DC voltage. Invented by Heinrich Greinacher in 1919, they were used in the design of a particle accelerator that performed the first artificial

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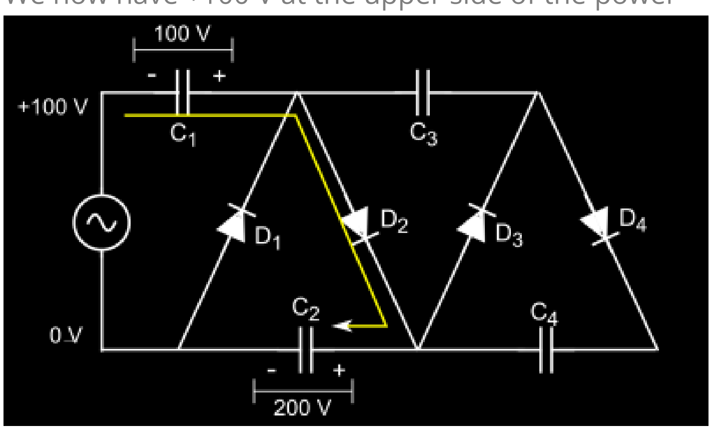
nuclear disintegration, so you know they mean business.

Theoretically the output of the multiplier is an integer times the AC peak input voltage, and while they can work with any input voltage, the principal use for voltage multipliers is when very high voltages, in the order of tens of thousands or even millions of volts, are needed. They have the advantage of being relatively easy to build, and are cheaper than an equivalent high voltage transformer of the same output rating. If you need sparks for your mad science, perhaps a voltage multiplier can provide them for you.

HOW DOES IT WORK?

The multiplier circuit needs an AC power supply in order to work. For the sake of simplicity let´s assume that one side of the power supply is grounded and remains at zero potential, and the other varies between plus and minus U (100 V in the example). Here's what happens:

1. Capacitor C1 charges through diode D1 at the voltage U (100 V) of the power supply, which is at its negative peak. Note that this leads the capacitor to be positive at its right side and negative at its left. The yellow line indicates the direction of current flow
2. We now have +100 V at the upper side of the power



supply, and this voltage adds to that of C1 that was charged in the previous step. Therefore capacitor C2 charges through D2 to 200 V, or 2U (100 V from the power supply plus 100 V from C2).

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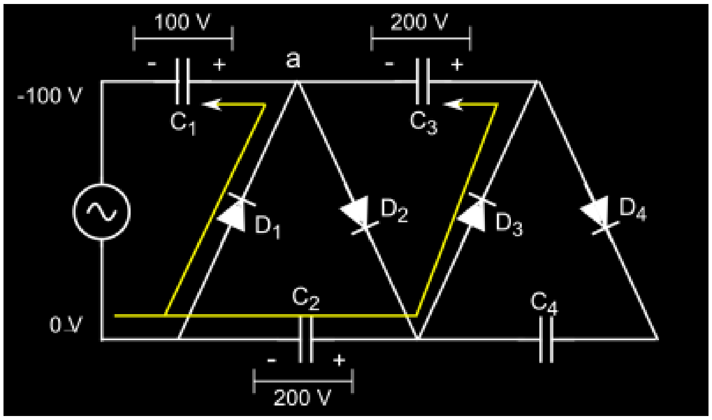
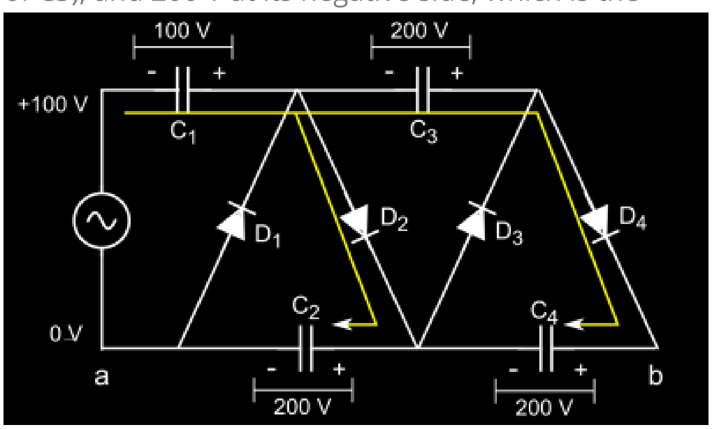
3. The charge stored in C1 was used in the previous cycle to charge C2, so C1 is now charging through D1 as in step 1. Also, capacitor C3 is charged through D3 to 2U. Why 2U? Because since C1 is discharged,



point "a" in the schematic is at zero potential and C3 sees the 200 V of C2.

4. The power supply is again at its positive peak, and C2 is now being recharged as in step 2. At the same time, capacitor C4 charges to 200 V, because it is the potential difference that it sees: 400 V at its positive side (100 V of the supply plus 100 V of C1 plus 200 V of C3), and 200 V at its negative side, which is the



potential of C2.

As we can see, we will end with 400 V between ground and the output (points a and b in the last figure), effectively quadrupling the supply voltage.

This is an idealized explanation, and as you may guess reality is always more complicated. For instance, capacitors do not charge instantly, therefore they do not reach the full voltage until several cycles have passed, depending on the charging current that the power supply can deliver.

September 2016
August 2016
July 2016
June 2016
May 2016
April 2016

The multiplier that we just discussed has two stages. Each stage is formed by two capacitors and two diodes and each one adds two times the voltage of the power supply, so for example a five-stage multiplier will have an output of ten times the input voltage. Note that each component in the circuit only sees at most twice the peak input voltage provided by the source, therefore you can use low voltage components and many stages to obtain a very high output voltage.

$$\Delta U = \frac{I}{fC}\left(\frac{2}{3}n^3 + \frac{1}{2}n^2 - \frac{1}{6}n\right) \quad \text{where} \quad \begin{array}{rl} \Delta U: & \text{voltage drop} \\ I: & \text{output current} \\ f: & \text{input frequency} \\ C: & \text{capacity of caps} \\ n: & \text{\# of stages} \end{array}$$

(c) Jochen Kronjaeger
www.kronjaeger.com

However, the output voltage will drop as soon as you connect a load to the circuit, according to this formula. Here we can see that we need high frequency and high capacitance in order to minimize voltage drop, and that this drop increases with current, and also very rapidly with the number of stages. In fact, since it depends on the cube of the number of stages, a multiplier with ten stages has 1000 times more voltage drop than one with a single stage.

Another situation that arises when very high voltages are present is corona discharge, which is an electrical discharge that arises when the strength of the electric field around a conductor is high enough. Corona acts as an unwanted load on the multiplier, reducing the output power. One way to minimize corona is to reduce the curvature in conductors, avoiding sharp corners, projecting points and small diameter wires. For this reason large diameter end points and conductors are used. This of course complicates the design of very high voltage multipliers but at the same time accounts for their impressive look, as in the feature image.

Making a voltage multiplier to obtain high voltage is a popular project and is pretty easy as long as the voltage is not too high for corona to start creating problems. All you need besides an AC power supply such as a neon transformer are some high voltage diodes and capacitors. Practical uses include X-ray machines,

photocopiers, air ionizers and microwave ovens, among

Homemade voltage multiplier, by [rmcybernetics]

others. At the high end of the spectrum are the multipliers used for research in particle accelerators, several meters in height, that can reach millions of volts.

The high voltage multiplier has a venerable history in particle accelerators, and even a Nobel prize in Physics was awarded for research that was possible thanks to it. However as new technology has arrived, in particular radio-frequency quadrupole systems, those magnificent multipliers have been retired. We sure will miss them, and of course that doesn't stop you from building your own.

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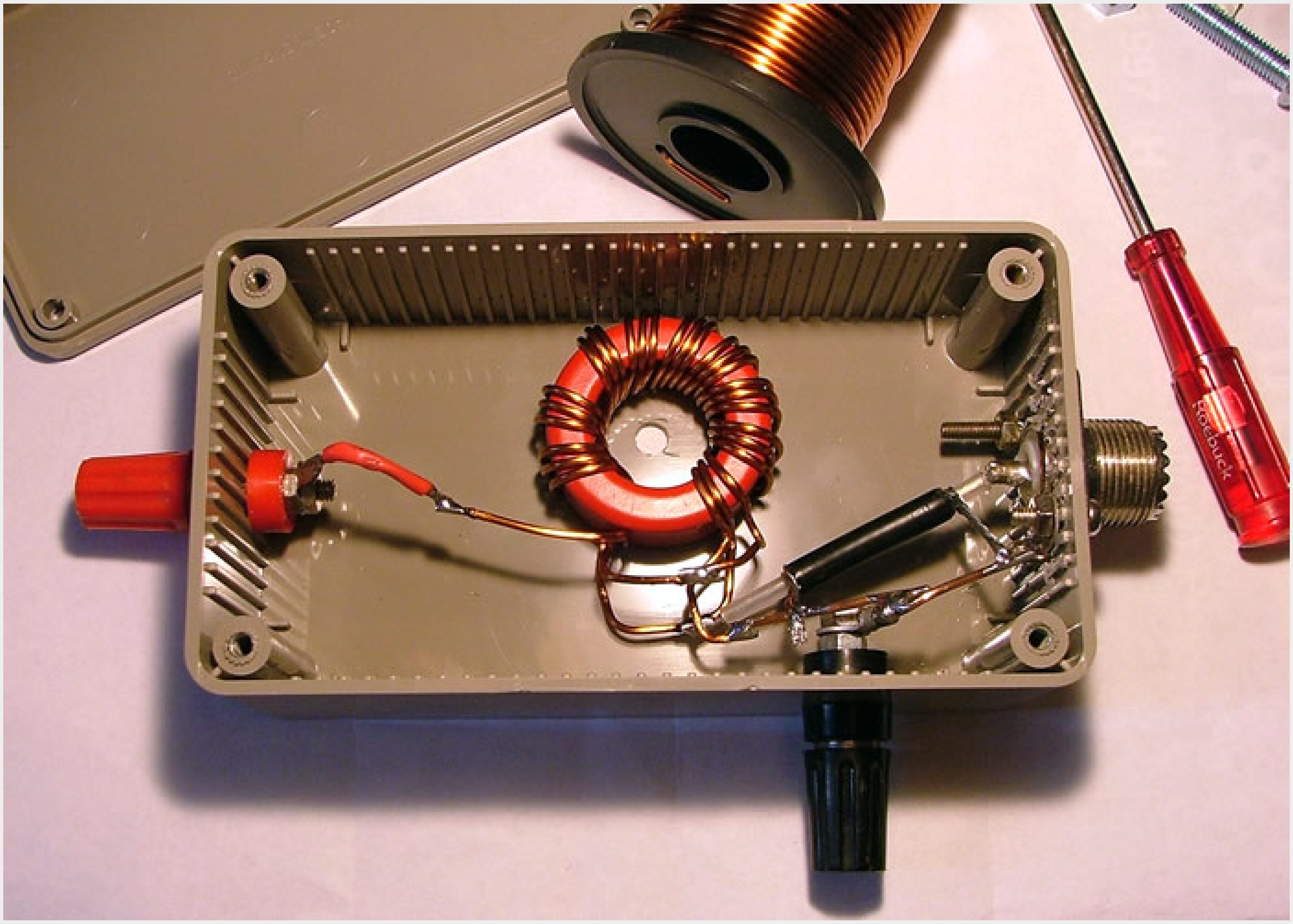
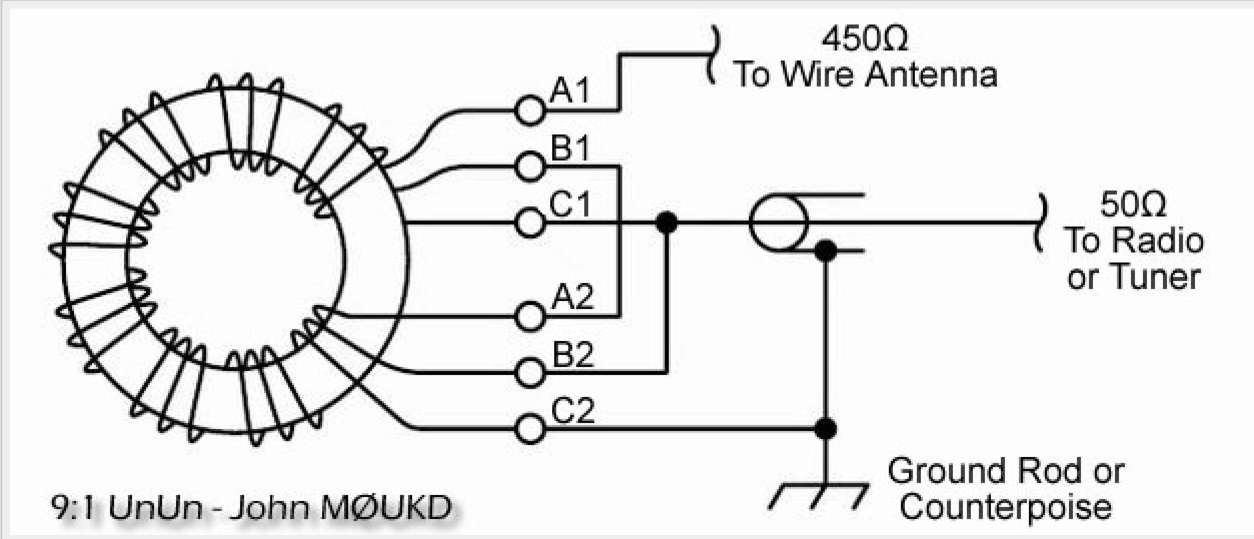
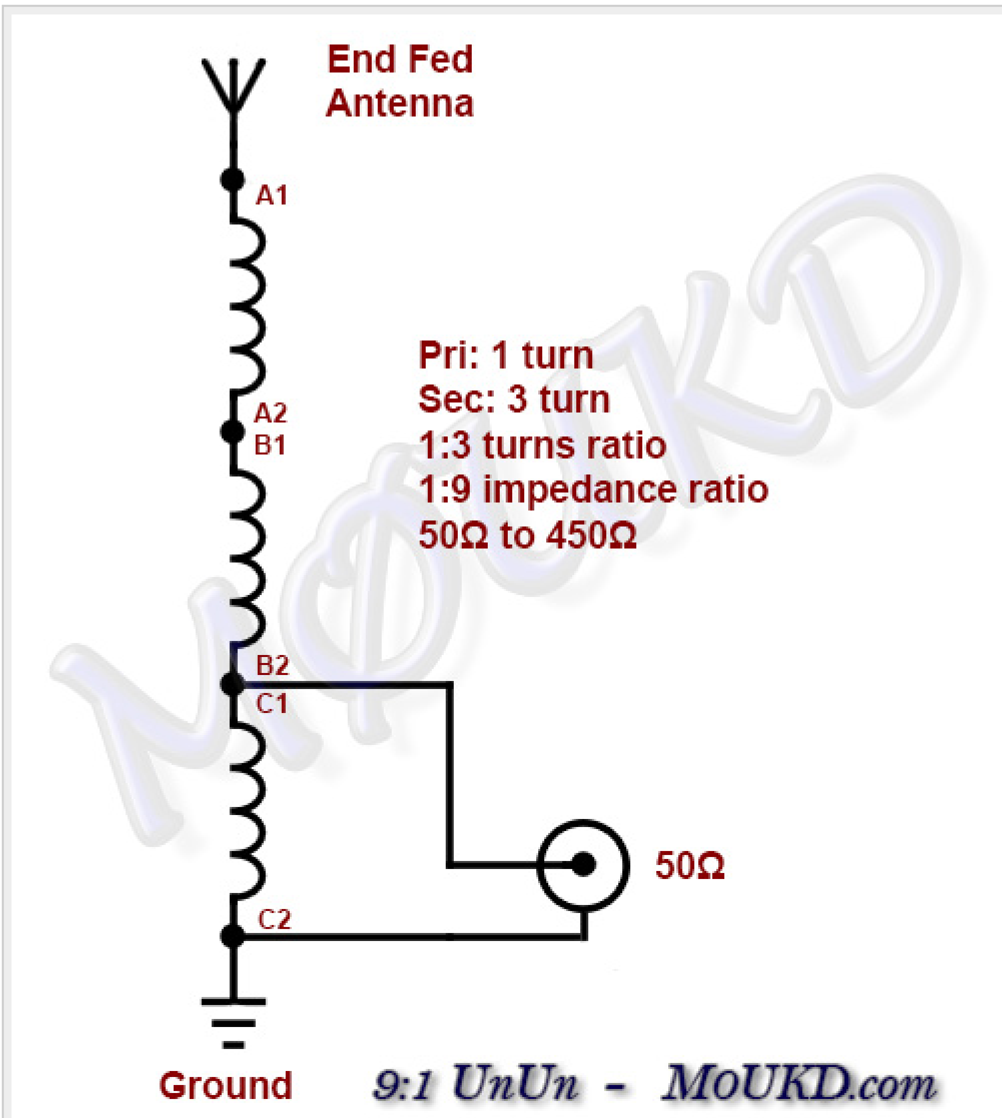
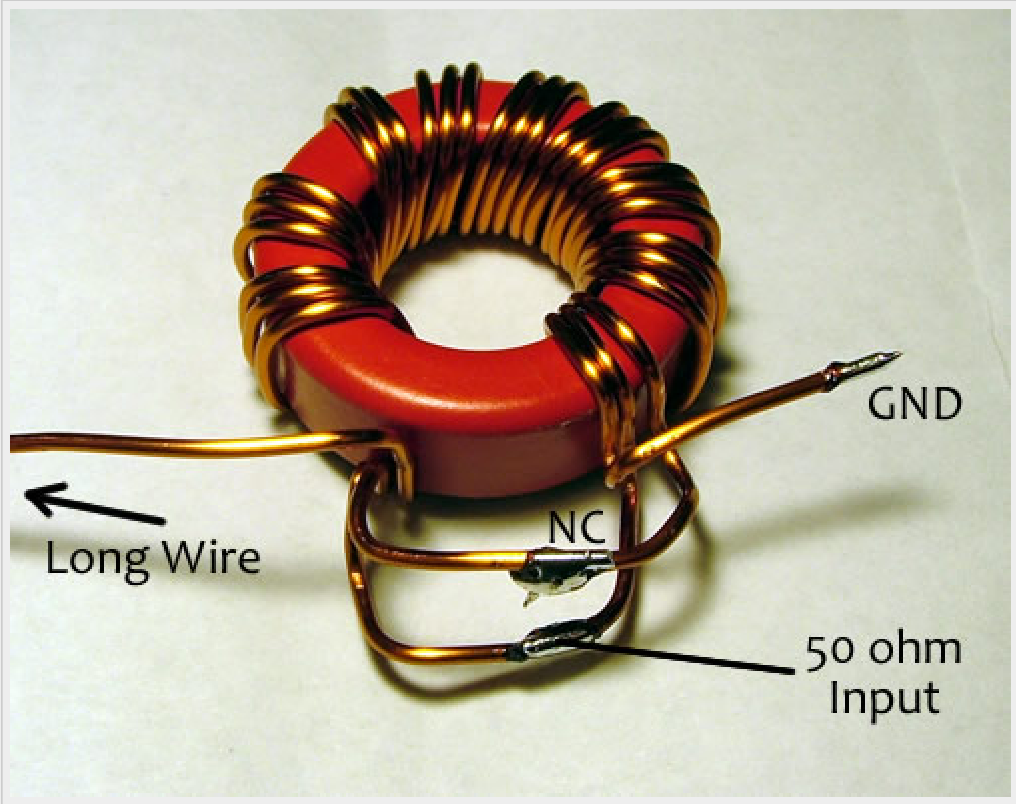
POST COMMENT

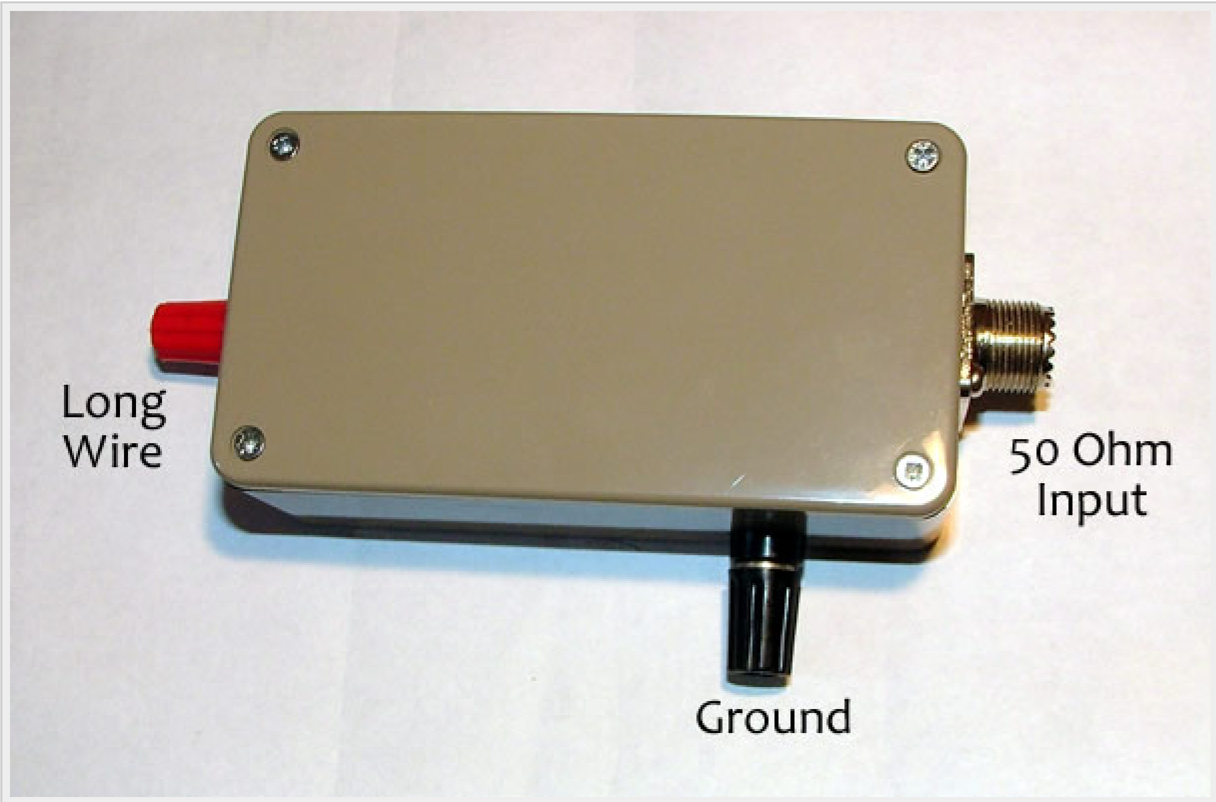
9:1 Magnetic Longwire Balun / Unun




450Ω
To Wire Antenna
A1
B1
C1
A2
B2
C2
50Ω
To Radio
or Tuner
Ground Rod or
Counterpoise
9:1 UnUn - John MØUKD


End Fed
Antenna
A1
A2
B1
B2
C1
C2
Pri: 1 turn
Sec: 3 turn
1:3 turns ratio
1:9 impedance ratio
50Ω to 450Ω
50Ω
Ground
9:1 UnUn - M0UKD.com

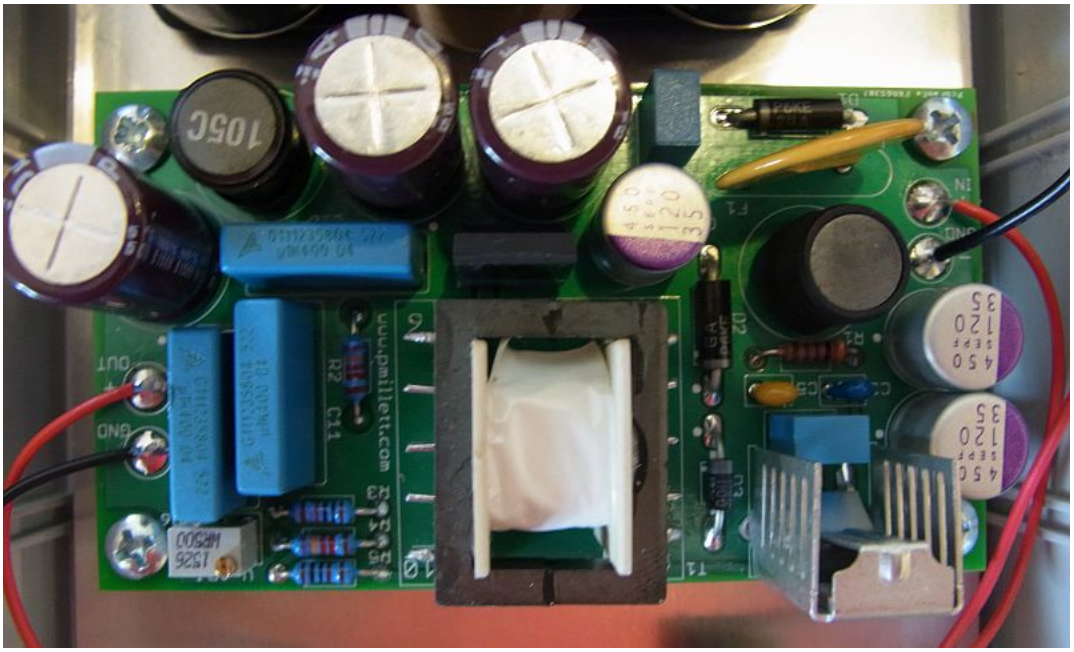

GND
Long Wire
NC
50 ohm
Input


Long
Wire
50 Ohm
Input
Ground

DIY Audio Home

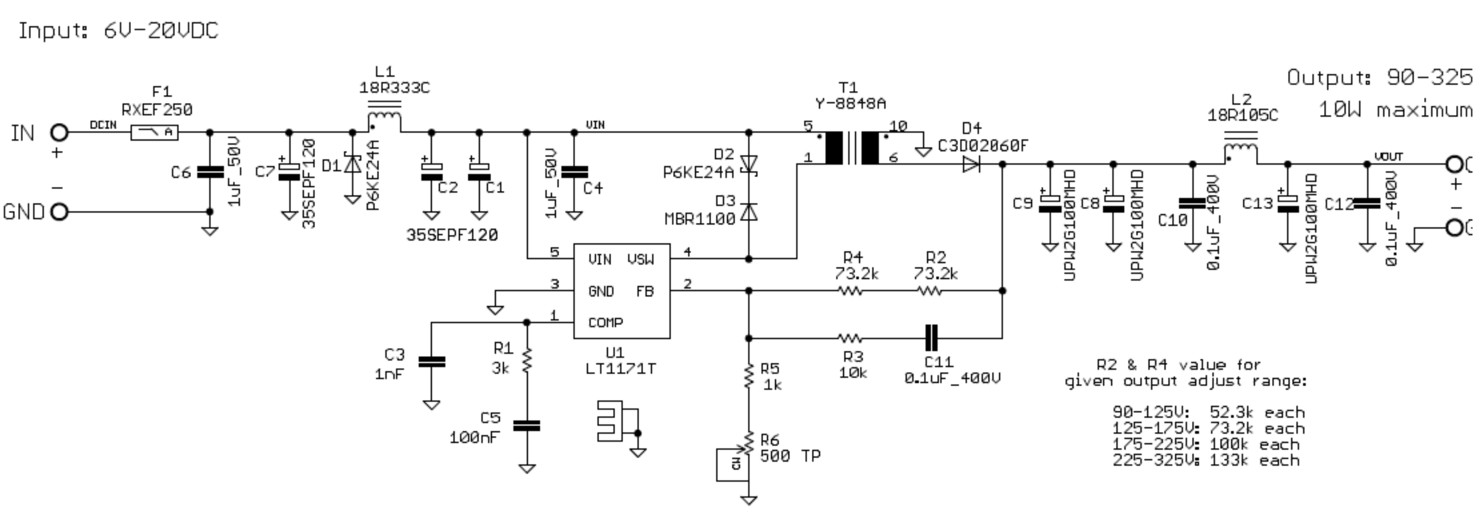
10W B+ Flyback Supply

This is a switching power supply to generate low-current B+ voltage from a low-voltage (5-20V) DC input. It is a non-isolated flyback converter (input ground is the same as output ground). It can generate about 10W of power, depending on input and output voltages.



I designed this to provide high voltage power for a line stage (preamp). I use it in "el escorpion", a line amp built in a cigar box. It's an easy, small, and relatively safe way of getting a B+ supply for a low-power tube project.

Here's the schematic (or download it in PDF):



The supply uses a Linear Technology LT1171 IC, which makes the circuit pretty simple. The LT1171 integrates the controller and the output FET, so all you need to add is the feedback, compensation, input and output components. I chose to make it non-isolated mostly to simplify the design, but I also think that the most common use of this is to generate B+ from a DC supply (like a car battery, or an external AC supply) that will also power the heaters, so isolation is not needed.

There are LC input filters on the input (to reduce noise coupled backwards) and the output (to reduce high frequency noise at the output). Switching frequency is 100kHz. The output transformer is an off-the-shelf unit from Coilcraft (Y-8848A) that is designed to generate 12V at 10W from an AC input of 85-265VAC. It is used here in "reverse", with the high voltage primary being used as the secondary.

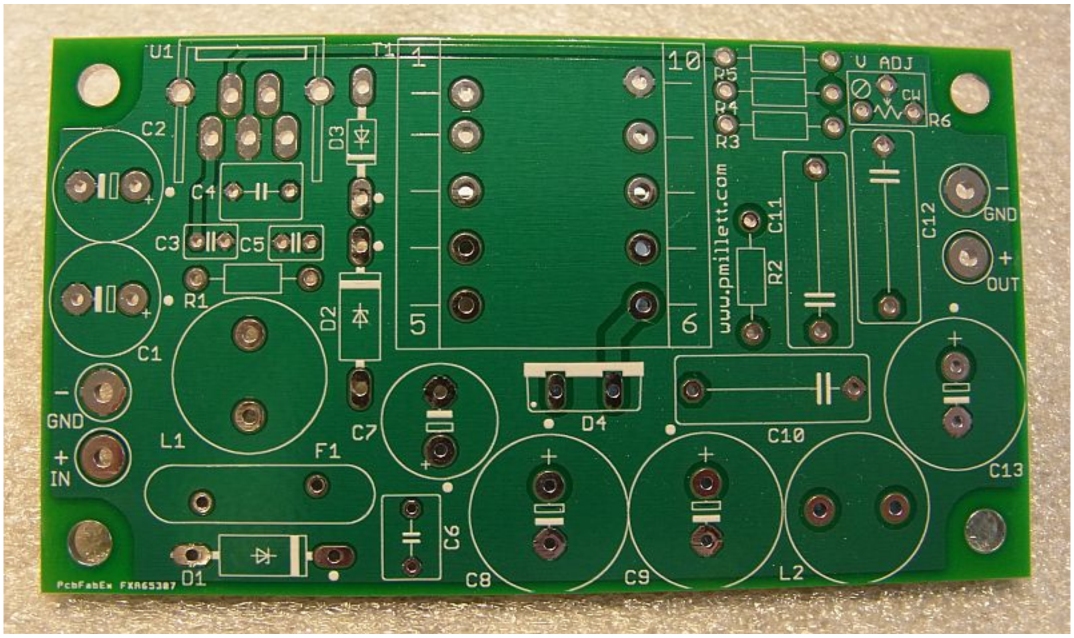
As I designed it, the output voltage can be set anywhere between about 90V and 325V. There is a trimpot to set the voltage and two resistors that are selected for the desired voltage range. I have not tried it but it should work up to about 400V. The maximum output current varies, depending on input and output voltage, but in general is constrained to about 10 watts. If you switch to an LT1170 IC which has a higher current limit, you may be able to squeeze out more power, but you may also start saturating the output transformer.

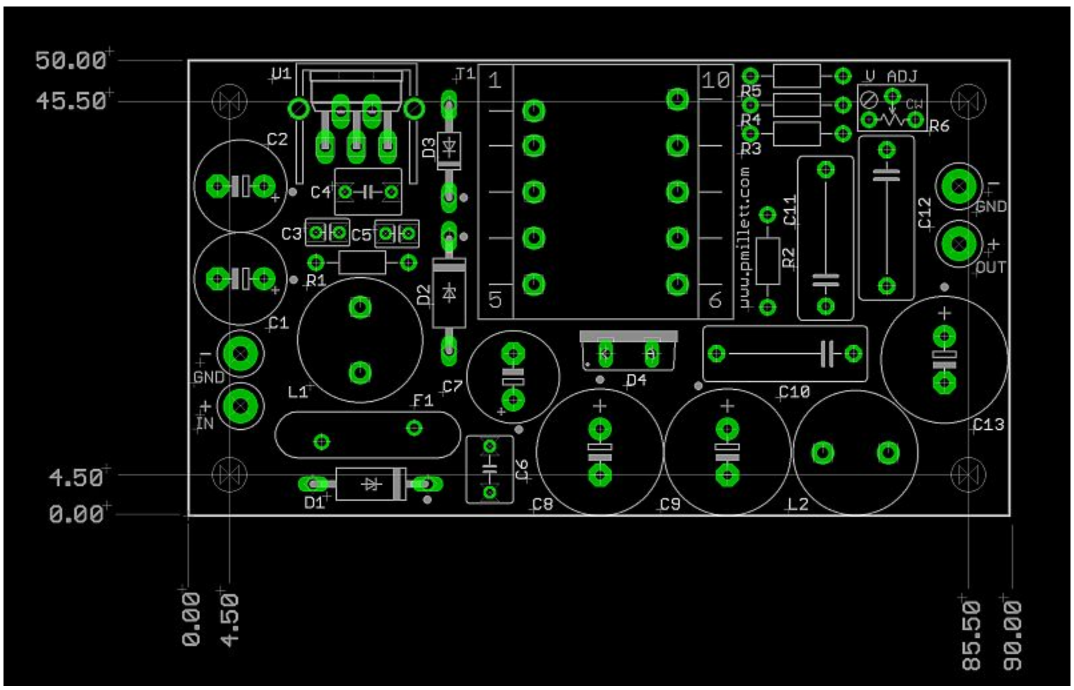
As is always the case, the compensation network is a compromise. I designed it by using LTspice, then tweaked it using actual measurements. I wanted the loop response to cross at a pretty low frequency - I want audio frequency currents flowing through the output caps, not being chased by the feedback loop. But you *do* want the loop to

respond to 120Hz ripple on the input supply, so it doesn't get through to the output. To verify the supply's response, I drive a signal back into the output, and sweep the frequency, while observing the output voltage. With the components shown the loop was benign throughout the audio band.

If you'd like to play with it in simulation, here is an [LTspice .ASC file](#).

The PCB is a simple through-hole board, 50mm x 90mm in size:





It's very easy to build. All parts except the transformer can be bought from [Digi-Key](#) - as mentioned above, the transformer can be purchased directly from [Coilcraft](#) (you can buy 1 piece through their web site).

Here is the parts list (BOM), in .[XLS](#) or .[PDF](#) format.

As usual, I will make these boards available from [my eBay store.](#)

BINARY DECIMAL LED DISPLAY VERSIONS OF THE SIMPLE FREQUENCY COUNTER

(2004)

Start of the construction of a new simple frequency counter with a binary decimal display.

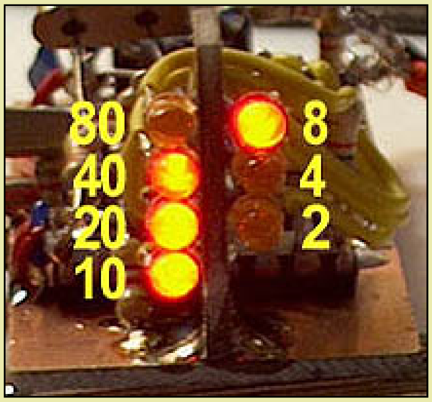
Why a new version of the LED display?
There are other display methods than the original 8 led frequency counter has. They are perhaps easier to read and may have a format that fits better to the front of your QRP equipment. Here some examples of binary decimal displays are given.

---

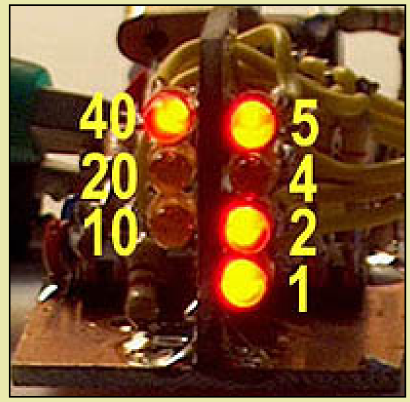
7 LED BINARY DECIMAL DISPLAY

(2004)

7 LED binary decimal display.
Mostly the the counter is made without the MHz position, only the kHz position is used to read the VFO frequency within a 100 kHz segment. This counter uses only 7 leds for reading the frequency in a 100 or 50 kHz segment. The counter starts counting at zero at each multiple of 100 or 50 kHz. Gating is done after the first /2 divider.
In this version, also the preamplifier is deleted and 74HC**T**390 chips are used instead of a 74HC390 for maximum sensitivity. The first /2 divider is adjusted for maximum sensitivity with a DC bias voltage. Gating is done after this first /2 divider. Of course it is also possible to use 74HC chips plus the RF preamplifier. In this case, the RF preamplifier is supplied by the 5V supply and not by the gating pulse. The advantage is that the RF amplifier is not switched on/off by the gating signal which might influence your VFO frequency due to the varying load.

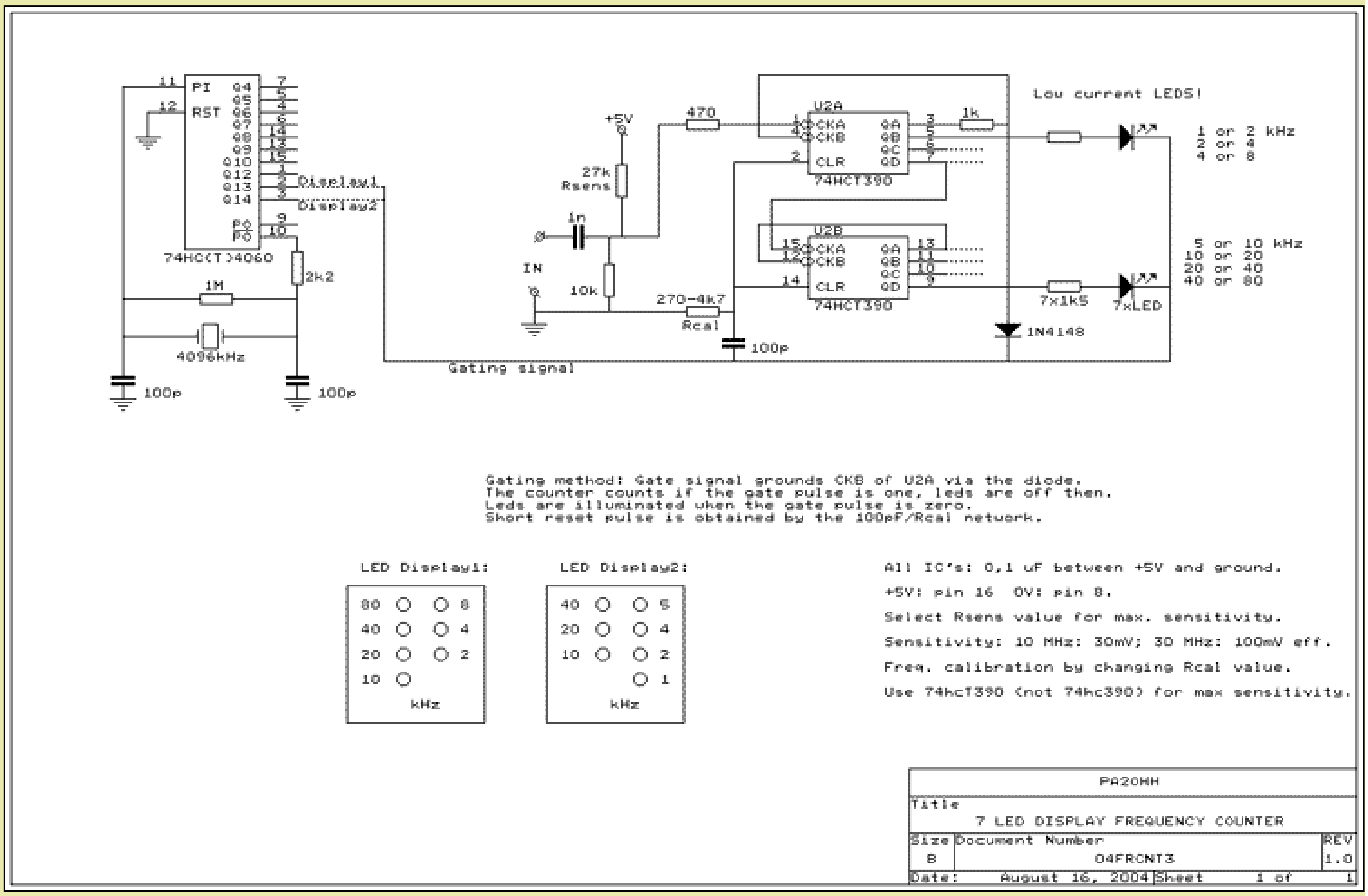


Reading your frequency with an accuracy of 500 Hz is possible as the least significant led (2 or 1 kHz) works like an analog scale.



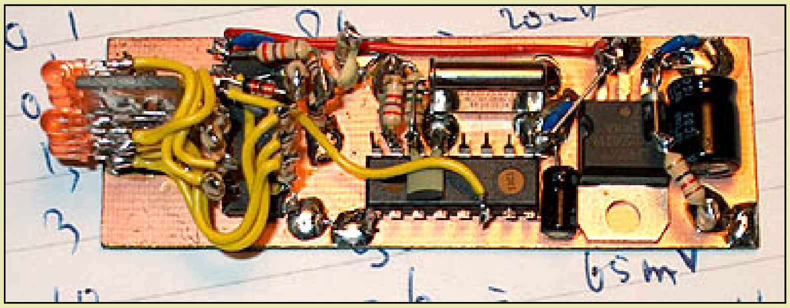
A display of 1, 2, 4, 8 kHz is also possible by placing the second /2 divider between the first /2 and /5 divider of the 74HC(T)390. Or: /2 /2 /5 /5 instead of /2 /5 / 2 /5.

The least significant led (2 or 1 kHz) works like an analog scale. It slowly varies in brightness when the frequency is changed. Therefore, the frequency reading is much better than the value of that led.



Circuit diagram of the 7 led display counter

big diagram



The experimental version of the 7 led frequency counter
including an extra 5V stabilizer circuit with a 7805.
This photograph shows good how very simple the counter is!

Calibration of the frequency counter
Select the Rcal value for a correct display of a reference frequency. See the 2x4 LED frequency counter above for an explanation.

Notes
Use 3mm low current leds.
You should build the counter in a screened box to avoid RF interference in your receiver!!

Performance.
At 30 MHz, the frequency error was +100 Hz. At 10 MHz, the error was -300 Hz.
Supply current is 3 to 7 mA, depending on the number of illuminated leds and the input signal.

Frequency (MHz)	Sensitivity (mV rms)
0.1	20
1	20
10	30
20	50
30	100
50	300
60	500
63	1000

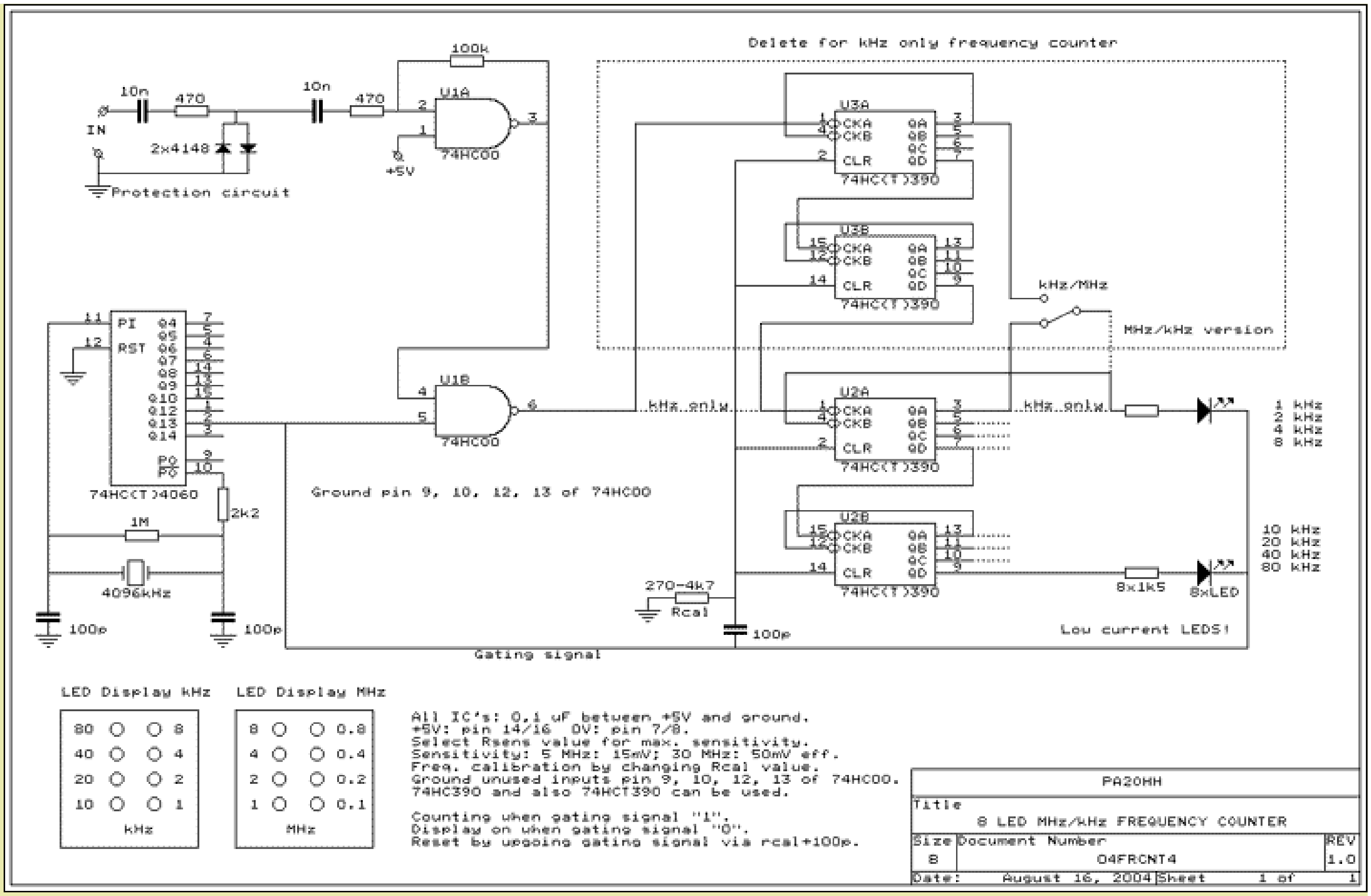
Note:
The sensitivity is quite good but for a reliable operation over a wide temperature range, the input signal should be at least 100 to 200 mV.

THE BINARY DECIMAL 2x4 LED DISPLAY

(2004)

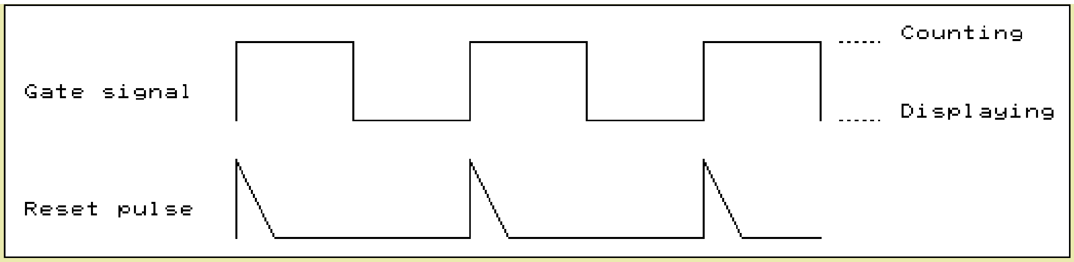
The binary decimal 2x4 LED display.
Instead of the original 8 led binary display, we can also make a 2x4 led binary-decimal display.
Here a more complex version of the simple frequency counter with 4 chips, it has a kHz and a MHz mode:

2x4 LED binary decimal display. The left row is the x10 kHz / x10 MHz display, the right one the x1 kHz / x1 MHz display.



Circuit diagram
[big diagram]

Working principle
The 74HC4040 in the original 8 led counter is replaced by a 74HC390. This chip has two /10 dividers so that we will have that new display with 2x4 leds instead of the 1x8 led display. A 74HC00 (do not use a HCT) is added, one NAND is used as RF preamplifier to increase the sensitivity and as buffer between the VFO and counter, another as an RF gate switch to start and stop the counter. The unused inputs of the two remaining NAND's are grounded. Using a 74HC00 instead of the transistor amplifier eliminates the problems with the settling time of the RF transistor amplifier of the original two chip frequency counter. The chip is even cheaper than the transistor but needs more supply current!
It works as follows: We reset the 74HC390, then count, then stop counting and display the frequency and then reset again etc.
The 74HC4060 oscillator with the 4096 kHz X-tal generates a frequency of 500Hz. Only the +5V half period is used for counting. During the +0V half period, the leds are displaying the frequency, during the +5V half period, they are off and the 74HC390 is counting the frequency. At the beginning of the counting period, the 74HC390 is reset by the short reset pulse from the 100 pF/Rcal differential network.
The gating is very critical as a 1 to 0 transition from the 74HC00 gate will cause an extra count. This does not occur when the gate switches off, then the output goes from 0 to 1 (or 1 to 1). But when the gate switches on while the input is 1, the output of the gate is changes from 1 to 0. However, during this moment the reset pulse is active, preventing that extra count.



Explanation of how it works: counting if gate signal=1, display frequency if gate signal=0.
The short reset pulse is made by the 100pF/Rcal differential RC network.

Calibration of the frequency counter
Normally, the calibration is done by adjusting the crystal frequency with a trimmer. But not here! Due to the 100pF capacitors, the oscillator frequency is lower than the crystal frequency. The resulting gating pulse is a little too long. But the frequency measurement time is the length of the gating pulse minus the reset pulse. Calibration of the frequency counter is done by changing the length of the reset pulse (depending on Rcal value). Select the Rcal value for a correct display of a reference frequency.

Notes
Use 3mm low current leds.
You should build the counter in a screened box to avoid RF interference in your receiver!!

Only barefoot simple tools were used for the construction of
the barefoot simple frequency counter with binary decimal display!

Performance.
At 30 MHz, the frequency error was +300 Hz. At 10 MHz, the error was 100 Hz. In the MHz position, the accuracy is the same as in the kHz position because the same gate pulse and reset pulse are used.
Supply current including a 78L05 stabilizer is 10 mA with an input signal and 50 percent of the leds on, 25 mA without input signal as the supply current of the 74HC00 is much higher without an input signal.

Frequency (MHz)	Sensitivity (mV rms)
0.1	40
1	10
5	15
10	15
20	25
30	50
50	150
60	200
80	500
85	1000

BACK TO INDEX PA2OHH

A PORTABLE REGENERATIVE RECEIVER

(2002)

[KLIK HIER VOOR DE NEDERLANDSE VERSIE]

The Portable Receiver and the smaller simple version.

The regenerative receiver was the first good shortwave receiver.
The regenerative principle was patented by Edwin Armstrong in 1914. Before 1940, this was the most used shortwave radio circuit for AM and CW reception. Positive feedback keeps the circuit on the point of oscillation. Under this condition the gain and selectivity are very high.
Nowadays such a receiver is history.... but not for some radioamateurs. Sometimes they want to experiment a little with radio technology of the past! For them, the tuning procedure with the regenerative control is part of the fun of operating this primitive radio.

The regenerative receiver with tubes.
Once I had a regenerative receiver with a triode EC92 and a crystal telephone. It worked well on 80 meters but needed good ears and a long wire. And I always wondered why a radio amateur a few kilometers away from my QTH often thought that someone was tuning in on his frequency! Well what he heard was my oscillating 0V0 regenerative receiver....

If I should build such a receiver nowadays, it would not be used a lot and end its life quite soon in the junk box, together with the quite expensive tubes and transformer.

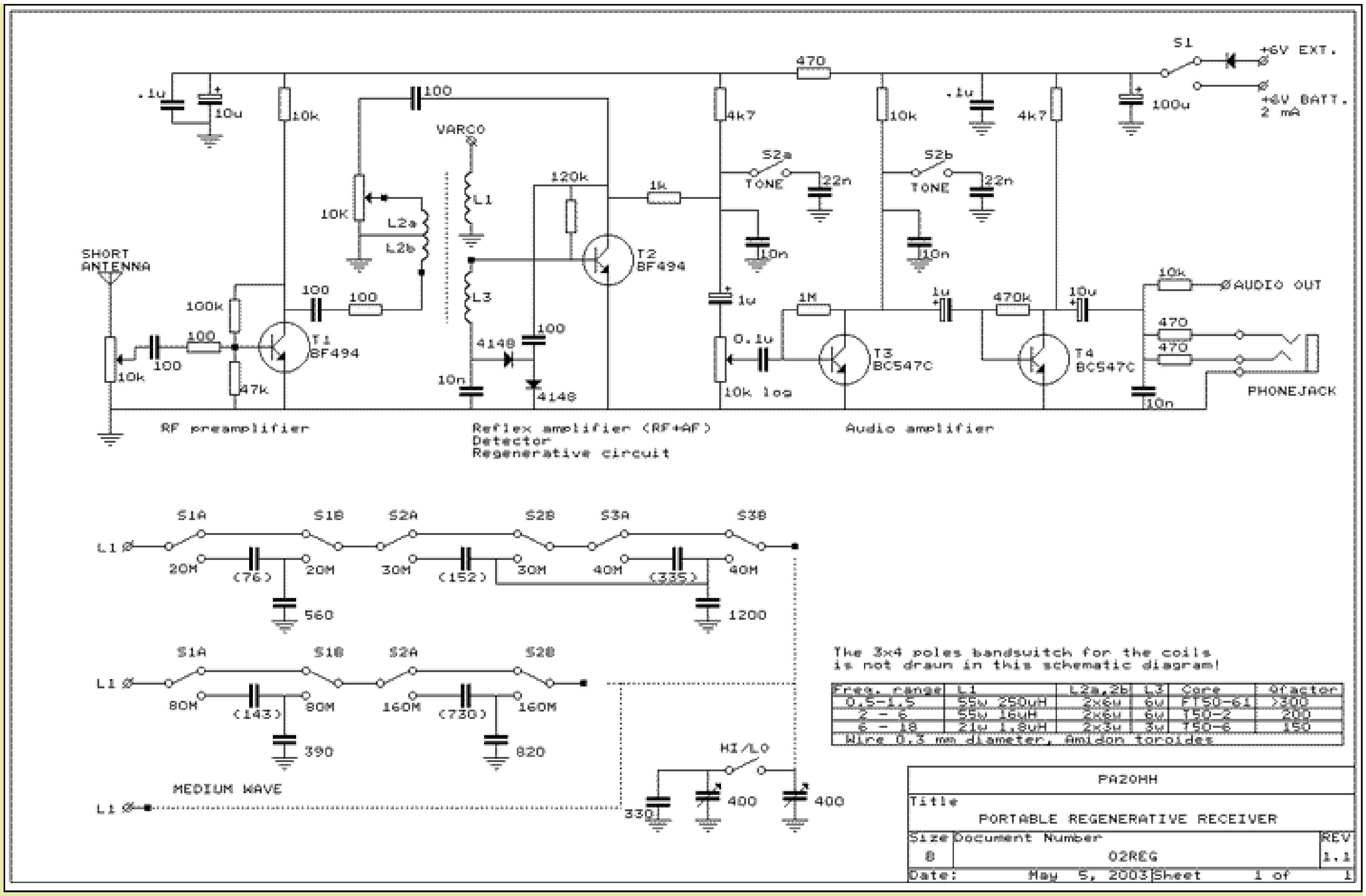
The PORTABLE regenerative receiver
Then I found on the internet an article of Keith Ranger, G0KJK, and I became interested. Keith had fitted his regenerative receiver with an antenna amplifier, so it does only have a short telescopic antenna.
And that was a nice idea! A portable ham radio according to the Regenerative principle. Very suitable for portable use due to the low power consumption of a regenerative receiver with transistors. Not a top performance receiver, just a nice toy for portable use.
Listening in the garden in the sun to all kinds of radio signals, locating interference sources or use it even as a receiver for a noise impedance bridge, it is all possible. How much fun can such a simple regenerative receiver give!

My version of the portable regenerative receiver
It is a modern portable version of the historical regenerative receiver, with transistors and a short telescopic antenna plus RF preamplifier. And it is a real QRP receiver, supply is only 2 mA at 6 volt. If you use it during two hours per day, the batteries (4xAA size) have to be replaced only once per year. Sensitivity is good, AF output is sufficient for standard 32 ohm stereo headphones. Due to the preamplifier there is almost no frequency drift when approaching the antenna. What a difference compared with my old tube receiver!
Reception of AM, CW, SSB and even FM is possible. It covers the Medium Wave and Short Wave upto 19 MHz, above that frequency the stability is not good enough for pleasant use. Trials showed however that the receiver worked at least upto 40 MHz.
To keep operating the receiver a pleasant activity, I made band switches for all amateur bands so that tuning is easy.

Outdoors Short Wave Listening (SWL) activity with the portable regenerative receiver.
Of course you want to know what you can receive with such a receiver. Me too and I went outside a few times to see what could be heard during one hour.

CLICK HERE TO READ WHAT CAN BE HEARD WITH THE REGENERATIVE RECEIVER

Realisation



Circuit diagram of version 1.1 with four transistors instead of five as version 1.0 had

big diagram

RF preamplifier

T1 is the RF preamplifier and also a buffer between the regenerative circuit and antenna. RF level is controlled by a potentiometer. The telescopic antenna is adjustable between 20 and 40 cm.

The first version had an extra RF preamplifier between the antenna and potentiometer, but one RF stage and some extra AF gain gave less problems with strong RF signals. In this version, the potentiometer attenuates all signals directly at the input. It is possible to use even full size antenna's without overloading the first RF stage by increasing the RF attenuation.

Regenerative circuit, detector and reflex circuit

T2 is the most active transistor in this circuit. Firstly it act as an RF amplifier. The amplified signal is detected by two diodes and the detected audio is also amplified by T2. T2 is thus not only an RF amplifier but also an AF amplifier. Such a circuit is called a reflex circuit and was used a lot when transistors were very expensive.

But T2 does more! It is also a regenerative circuit. Part of the RF output level is fed back to the input by the regenerative control potentiometer. Gain and selectivity increase enorm due to this regenerative process. For AM reception the control is set to "just not oscillating". For SSB and CW it should just oscillate.

Oscillation can be controlled very smoothly, due to the negative voltage from the detector to the base when oscillation starts. Gain of T2 will be reduced by this negative voltage.

Automatic Volume and Selectivity Control

Indeed, there is automatic volume and selectivity control for AM reception in this simple circuit. When the signal level increases, gain of the transistor reduces due to the negative DC voltage from the detector. Due to the regenerative feedback principle, the gain of the total circuit varies considerably more than that of the BF494 transistor alone.

Also the selectivity changes. So if the station becomes weaker due to fading, the gain increases and also the selectivity. When the station becomes stronger, gain decreases and also selectivity, giving better reception quality of the higher audio frequencies.

Audio amplifier
T3 and T4 are BC547C transistors. Use the C type for more AF gain. Tone is controlled by a switch. There is also an audio output for a connection to the PC soundcard or external audio amplifier etc. If you want more audio level, simply connect the two earpieces of your headphone in series and replace the two 470 ohm resistors by one of 220 ohm.

Tuning circuit
The band switches create a rather comfortable tuning range of each band. But it is also possible to tune a whole shortwave band with very coarse tuning. Fine tuning for SSB and CW can be done by varying the regenerative control a little.
Adjust the values of the inductances and capacitors, number of switches to your variable capacitor and desired bands, it is not so critical. My 400 pF capacitor is in fact too much for the shortwave band 6 - 19 MHz, 200 pF is better, gives a higher Q.
Of course you do not need to use toroides, all kinds of coils are suitable.
L1 is wound around the toroide, L3 is at the cold (ground) side of L1, L2a + L2b at center position of L1. If regeneration does not occur or if noisy oscillation only happens with the 10k regeneration control at maximum, reverse the connections of L3.

Antenna
The receiver is very sensitive and you should expect that a lot of weak DX stations can be heard. But that is not the case. The receiver can only be used with short telescopic antennas, full size antenna's will cause a heavy overload of the receiver when the RF attenuator is not used.

Interference by strong FM broadcast transmitters
On a few locations, interference was caused by strong FM broadcast transmitters. This could be solved by connecting a 10 pF capacitor between the base and emitter and another 10 pF capacitor between collector and emitter of T1, the RF amplifier transistor. And the 100 ohm resistor at the base of T1 is increased to 330 ohm.

Notes
Built via the ugly method (dead bug method). Parts are soldered at one side of the print.
If you have too much regenerative feedback, place a resistor in series with the tickler coil L2a to the potentiometer.
I inserted a 10 ohm resistor after S1 (power switch) as a kind of fuse. And of course, the external power supply is really unnecessary for a supply current of only 2 mA!

How to use the receiver
Just a matter of experience. For AM reception the regenerative control is set just below the point of oscillation. For strong AM signals, decrease the AF gain and for very strong AM signals even the RF gain. For weak SSB and CW signals, set the regenerative control just above the point of oscillation. For stronger SSB and CW signals, increase the amount of oscillation to prevent overload.
Play with the RF and AF potentiometers for best performance. For CW and SSB, I use a low RF gain and high AF gain, for AM reception maximum RF and less AF gain.
Fine tuning can be done by varying the regenerative control a little.

PHOTOGRAPHS

(Click to enlarge)

Inside the receiver.

Front view.

Frequency bands, side view.

PERFORMANCE

A lot of hours have already been spent with listening to this receiver with pleasure! Considering that it is a very simple receiver with very low battery consumption and that a telescopic antenna of 40 cm at floor level is more a dummy load than a DX antenna, it performs good. But do not compare it with a good receiver plus antenna. It is not good enough for reception of weak signals, only stations of average strength can be heard.
Medium Wave reception is much better than expected. The sensitivity is perfect, selectivity is good enough. I was not shure if the ferrite toroide could be used, but frequency is not instable and the Q is more than 300! A lot of AM stations are heard with the antenna of 40 cm. Performance is comparable with a simple AM portable.
For 160 and 80 meters, performance is good. Sensitivity is okay, for CW the tone switch is a nice feature, frequency stability is good enough for a very pleasant reception of SSB and CW stations.
Also 40 meters is a nice band, good for a lot of Europese stations and even WB1 and VE3 are heard.
At 30 and 20 meters, stability is less but still good enough for CW and SSB reception. Some retuning due to frequency drift is necessary.
Due to the big tuning knob (1.5 rotation for a complete amateur band) and band switches for each amateur band, tuning is nice and easy. At 40, 30 and 20 meters there is sometimes some annoying interference from very strong broadcast stations during short periods, but it is still possible to receive a lot of stations or just switch to another amateur band.
Thanks to the low power consumption and the RF preamplifier, the oscillating regenerative receiver does not cause any interference to other radio amateurs as happened with my old tube receiver.

Oscillator level at antenna input: Maximal -68 dBm measured at 19 MHz, that is 11 dB lower than the official limit for receivers.
Sensitivity: CW signals of -130 dBm (0.05 uV) are readable on all shortwave bands.
Supply current: 2 mA at 6 volt.

Edwin Armstrong who invented the regenerative radio in 1912.

ACTIVITIES WITH THE REGENERATIVE RECEIVER

Amateur Radio
Many QSO's are heard on all amateur bands while portable, also Hell and even some PSK31 on 80 meters is received. However for serious Hell and PSK31 trials there is too much interference from the PC and monitor to the nearby telescopic antenna.

Interference sources
Within a few minutes, two interference sources were located in the shack, an electronic lamp and the PC plus monitor, even if they were switched off. The interference disappeared when the mains plugs were disconnected. One day later the satellite dish receiver was located as 80 meter interferer.

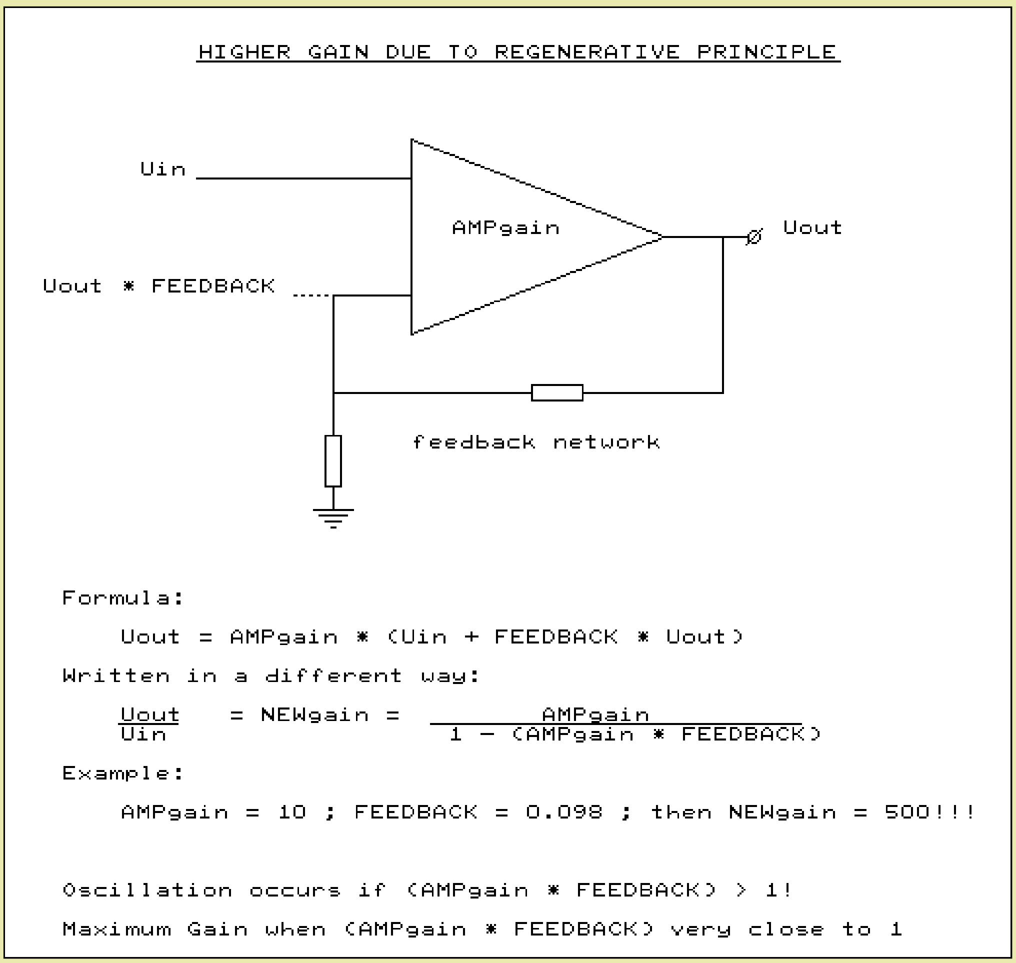
Adjustment of oscillators
Adjustment of oscillators of the frequency counters are easy with this receiver, just zero beat the oscillator signal with the reference frequency source at 10 MHz.

Radio repair
The local oscillator signals of broadcast radio's and the 455 kHz and 10.7 MHz IF signals can be monitored by the regenerative receiver.

EXPLANATION OF THE REGENERATIVE PRINCIPLE

Operating a regenerative receiver is much more interesting if you know someting about the working principle of the regenerative process. An easy understandable explanation is done by the next simple formula.

Increase of the gain



Maximum gain if the regenerative control is set to "just oscillate" or "just not oscillate" position.

Increase of the selectivity

```
    HIGHER SELECTIVITY DUE TO REGENERATIVE PRINCIPLE

Small changes in FEEDBACK cause much changes in NEWgain

Example:

   AMPgain = 10 ; FEEDBACK = 0.099 ; then NEWgain = 1000

   AMPgain = 10 ; FEEDBACK = 0.098 ; then NEWgain = 500!!!

   1% less feedback (0.09 dB) then 6 dB change in NEWgain

Selectivity:

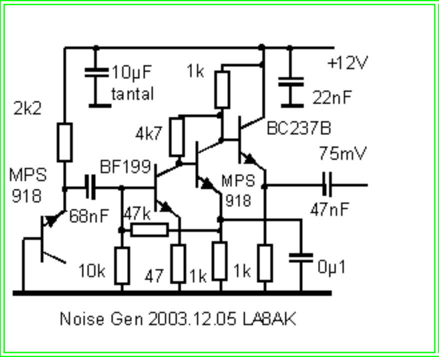
   FEEDBACK via resonant circuit! Then in above given example
   the new -6 dB points are the old 0.09 dB points!!!
   Selectivity significantly improved!!!
```

Maximum selectivity too if the regenerative control is set to "just oscillate" or "just not oscillate" position.

BACK TO INDEX PA2OHH

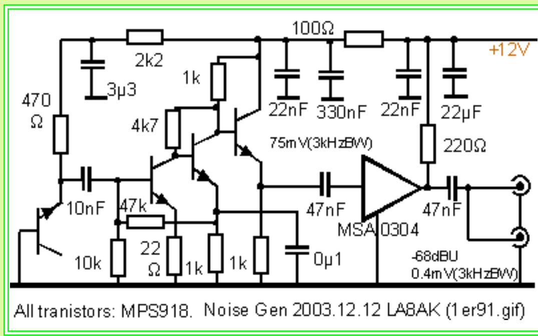
LA8AK

Noise measuring equipment

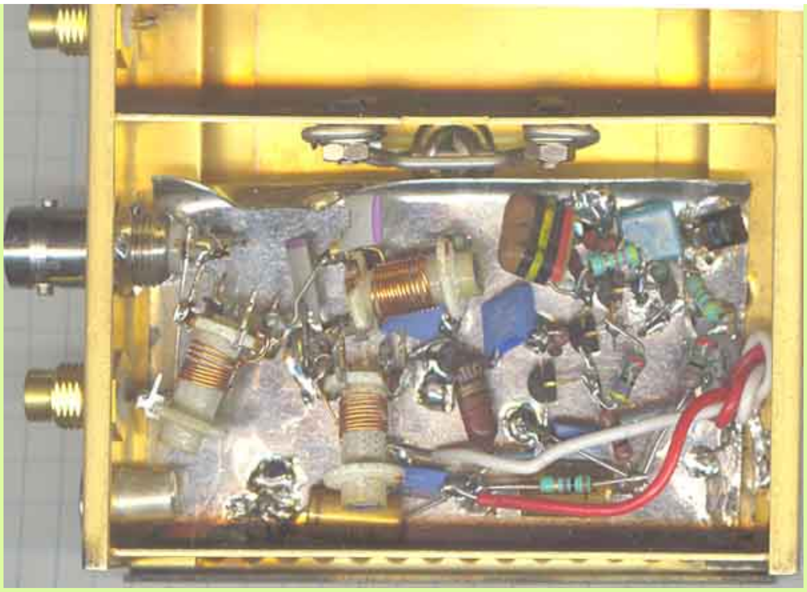


White Noise generator (I) for HF receiver selectivity checks

Noise level measured into 75ohm 3.1kHz BW using Siemens D2006 level meter: -80dBU (77.5mV) from zero to 1MHz and drops 3dB on 17MHz. Decrease the first coupling capacitor (68nF) to 10nF to increase the lower limit to 50kHz. The amplifier is copied from one of LA7MI's constructions, combined with a general audio amplifier. A noise level was needed to test vintage receivers and requirement was not beyond 10MHz, but it seems that some further bandlimiting circuit could well be used, particularly since I am not interested in noise spectre below 200kHz.
Picture: Zenerdiode connected (E-B junction) MPS918 at left side and the other devices follow as on the circuit diagram. The component values were first calculated, but I used the components which was closest, but it seems to cause no problem because of the heavy DC feedback. Reducing first emitter resistor (from 47 to 22Ω) to the half value will increases the output by 3dB on the lowest frequencies.



White Noise generator with MSA0304 booster amplifier. The picture shows the 1st version noise generator which has -68dBU 75 ohm o/p (3.1kHz BW), while the 2nd has -66dBU (rel.0.775V).



White noise generator II.

The 2nd version built on tinned iron plate, output is measured using Siemens D2006 selective level meter to -66dBU 75Ω (3.1kHz BW), and 30mV into 50Ω using LA7MI broadband voltmeter (described further down this page). Suppose this is quite high level and I am not sure if it is worth increasing it further since the main task is to check surplus receivers. Level on 10MHz has dropped by 2dB.
The noise generators were housed in NERA surplus boxes, and the 2nd room is not used.
Have kept the conhex connectors since they are free and available in very large quantities as well as different cablelengths with connectors.
It is some some minor changes of components for the two different versions. It increases the gain by 3dB, without any noticable change of frequency response, but the only measurable difference is that the version has 3dB, so it seems no problem to copy the circuits, the only importance is to choose a device with 6v e-b breakdown voltage. The box measures 100x80x30mm

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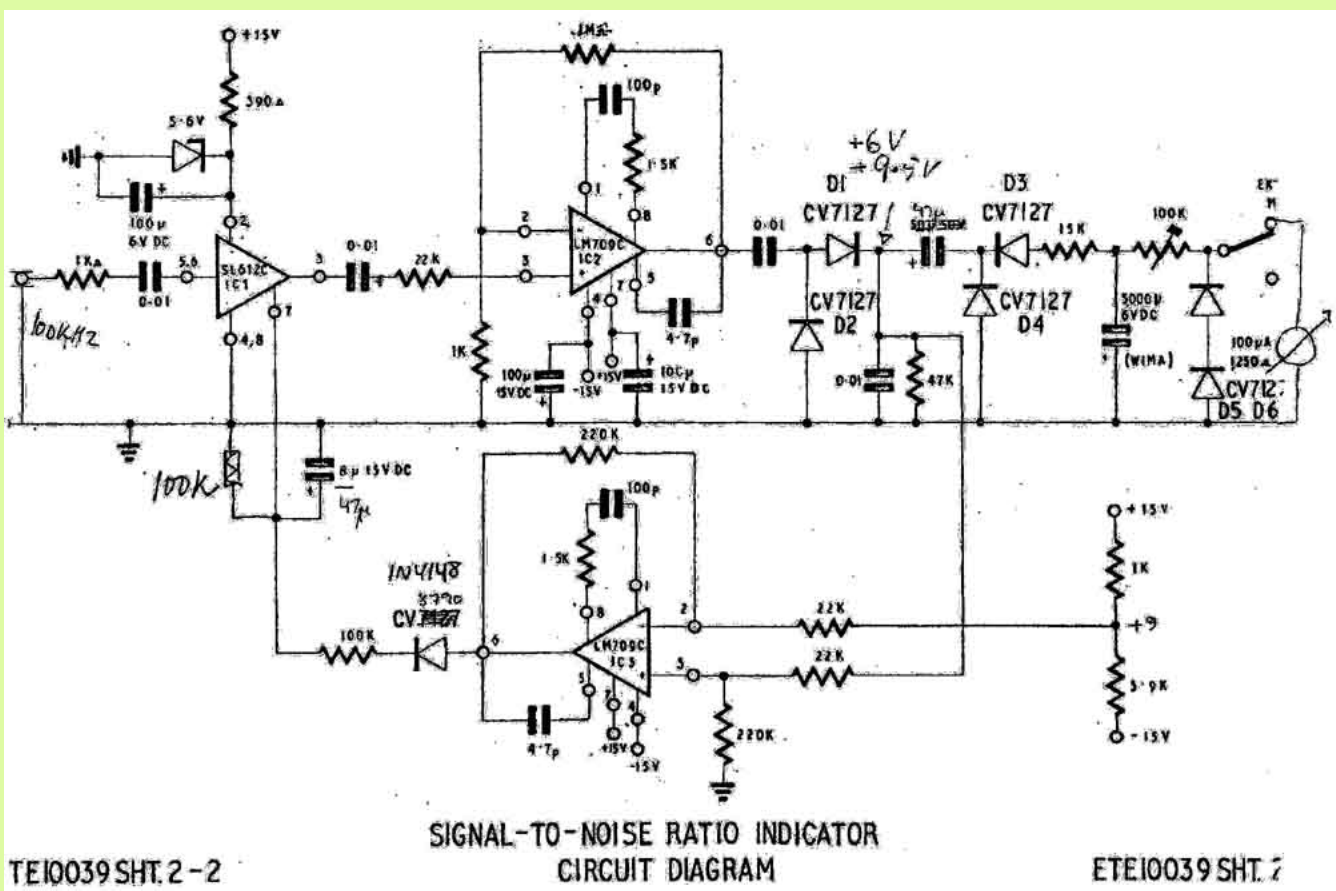
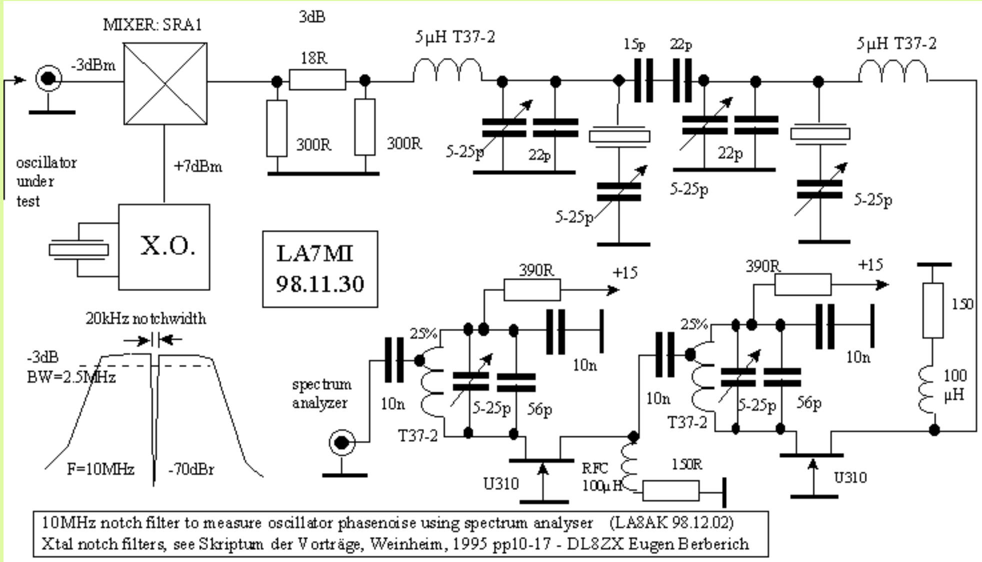


Signal-to-noise ratio meter (indicator), circuit diagram [anno 1972]

100kHz input e.g. Racal RA17 or similar receiver. Measures degree of noise-modulation on a carrier and feed it through a logarithmic detector. Could possibly be made using more advanced technique.....



Stein Torp LA7MI instrument with notch filter on 10MHz to measure oscillator phase noise. Sorry, the text is not available now.

Reference: Eugen Berberich DL8ZX. "Quarz-Notchfilter für Oszillatorrausch- und Intermodulationsmessungen im UKW-Bereich."
[Scriptum der Vorträge, 40. Weinheimer UKW-Tagung 16./17. September 1995 (DARC OV Weinheim), Seite 10 ...17]

Dubus Technik VI (year 2004). Leif Aasbrink, SM5BSZ. Receiver Dynamic Range, Part 7, pg 356. Crystal Notchfilters [but we do not understand why he doesn't use trimmer capacitors in series with the xtal and avoids buying several douzen xtals]

Noise Figure calculation table

FIGURE 1 – ATTENUATION, dB vs. α

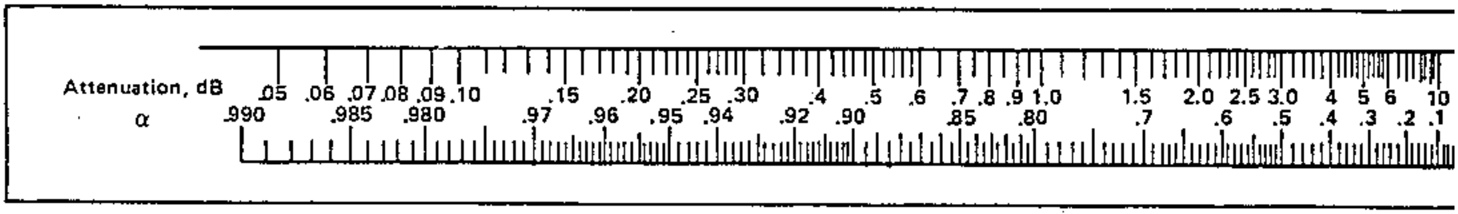
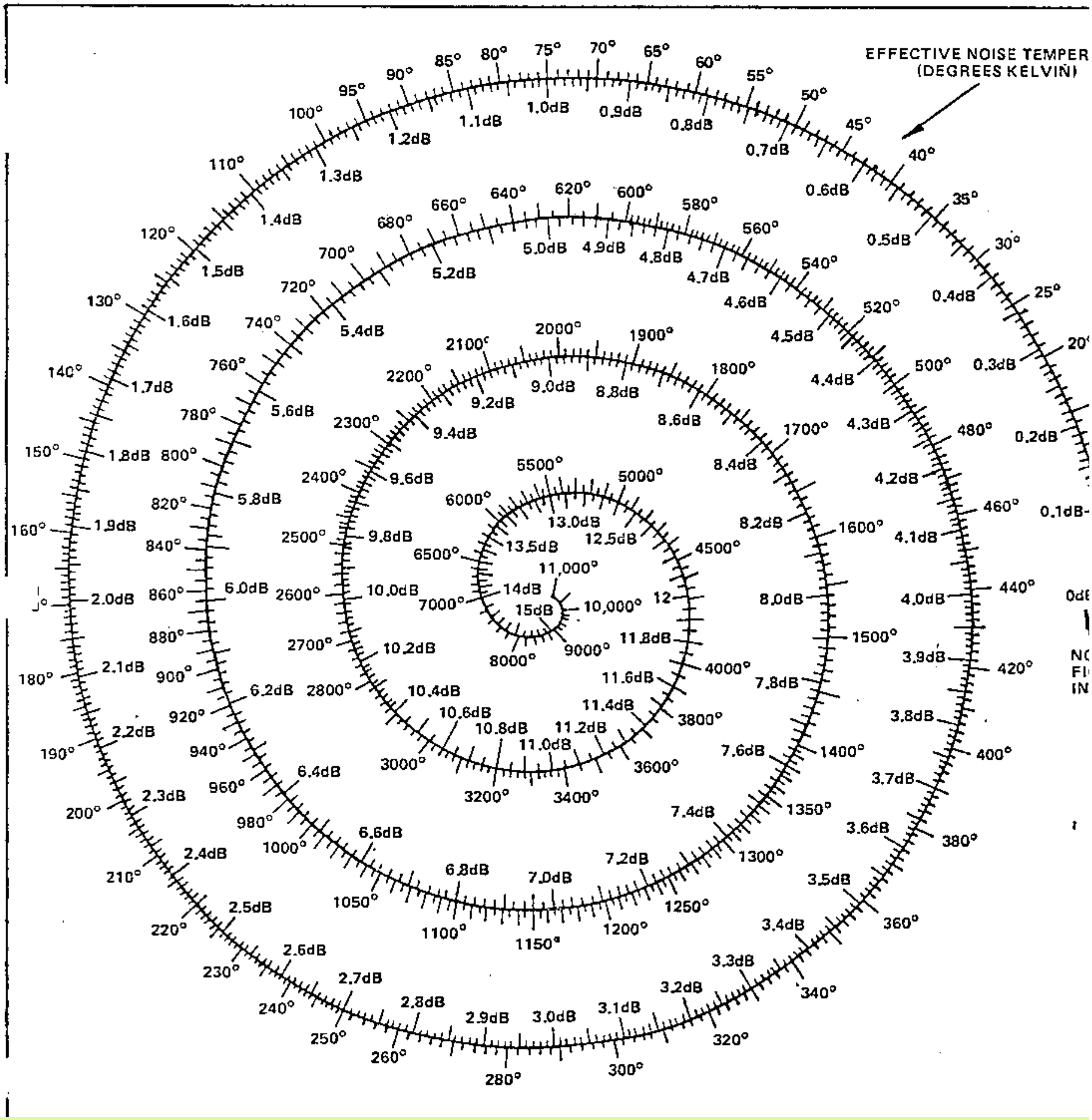


FIGURE 2

System Noise = $10 \log_{10}$ (KTsys B) +30 (K = 1.38×10^{-23})

FIGURE 3 – NOISE FIGURE VS TEMPERATURE



Noise figure calculation chart to calculate the overall improvement when you change the input stage
NF or gain in a receiver (will print better than it looks on the screen).

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pg-994 index for technical topics

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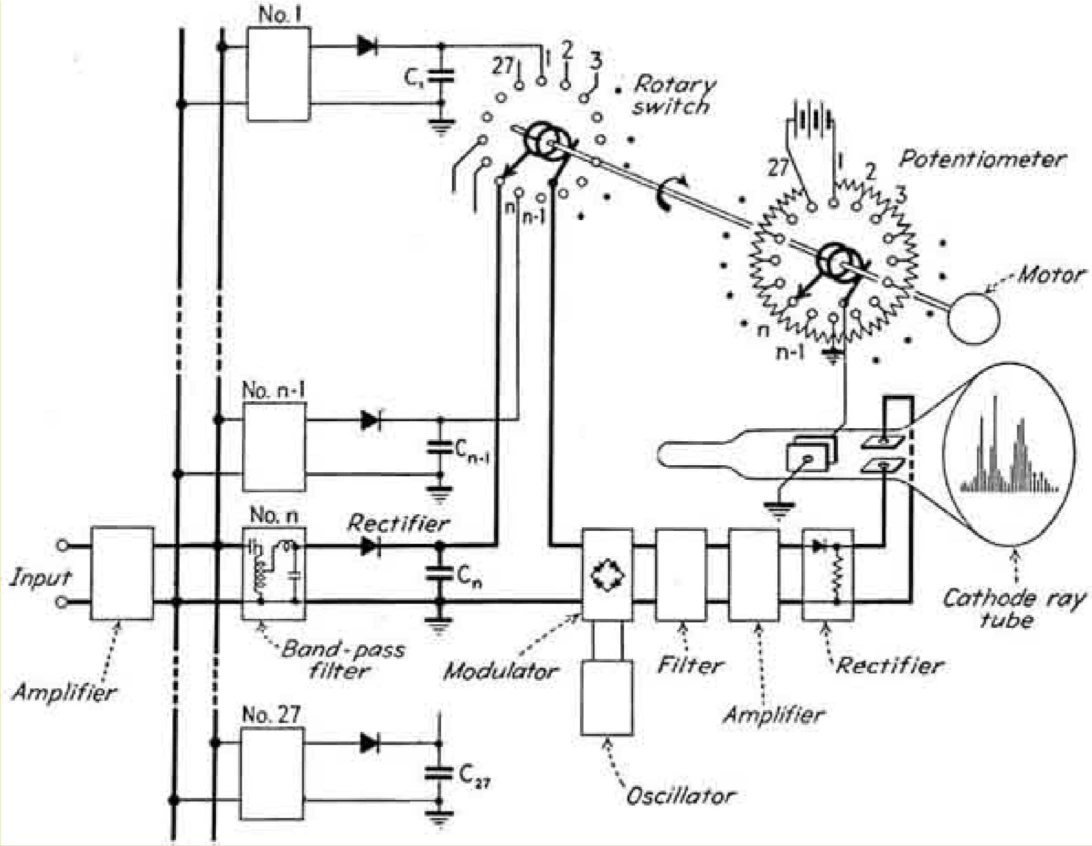
BACK

Last update: 2004.09.23

LA8AK

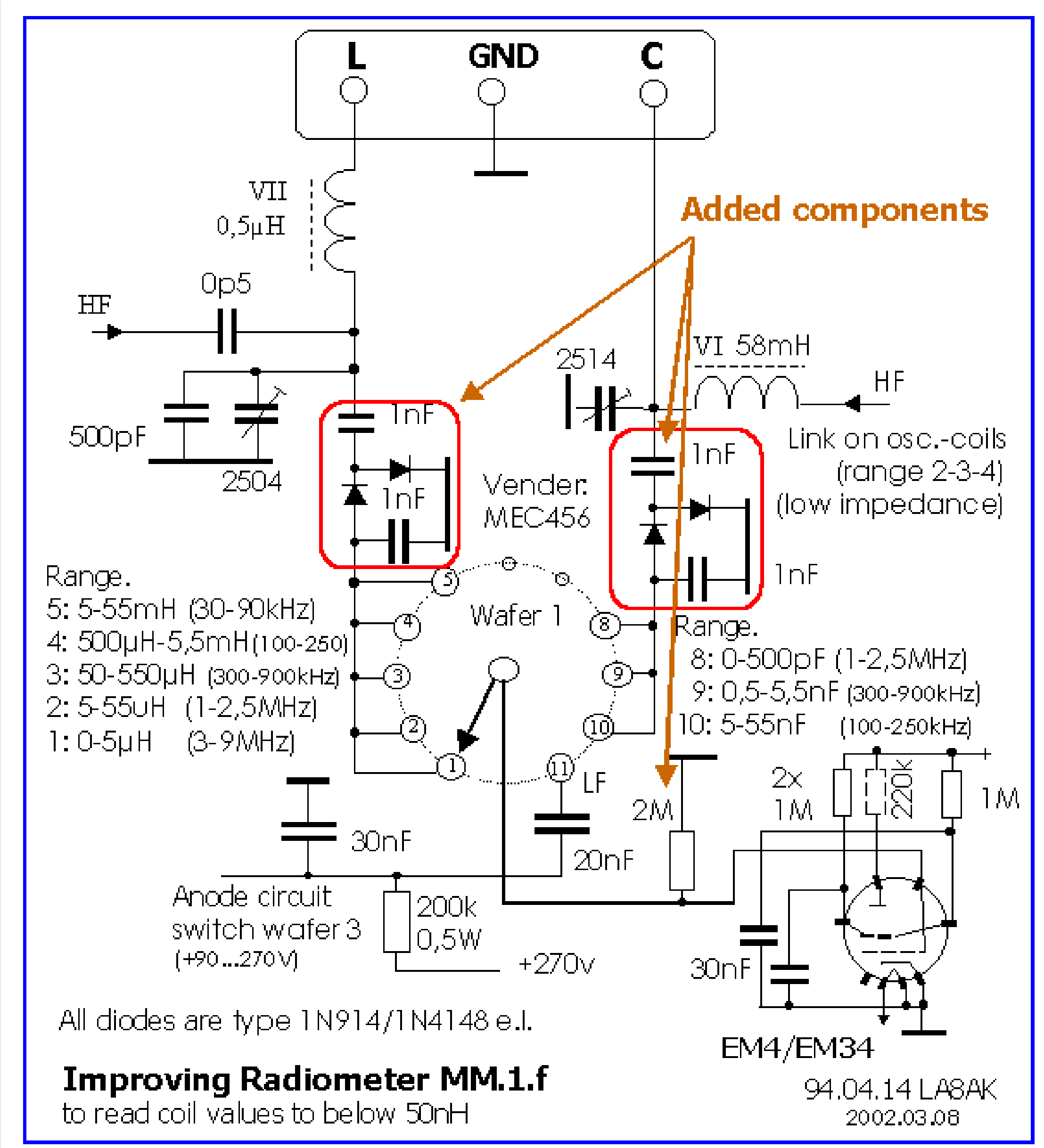
m22. Old measuring instruments - XXII

22.1)



Audio frequency spectrum analyzer anno 1939.
In *Electronics* November 1939 pg. 76-77 is an article with "Diagrammic representation of the functioning of the audio frequency
spectrometer. Only one bandpass-filter is shown although twenty-seven are employed in practice, The spectrum appears on the screen
of a cathode ray tube.

22.2)



Radiometer Multimeter MM1f modification for better reading for 0.05-1µH inductance

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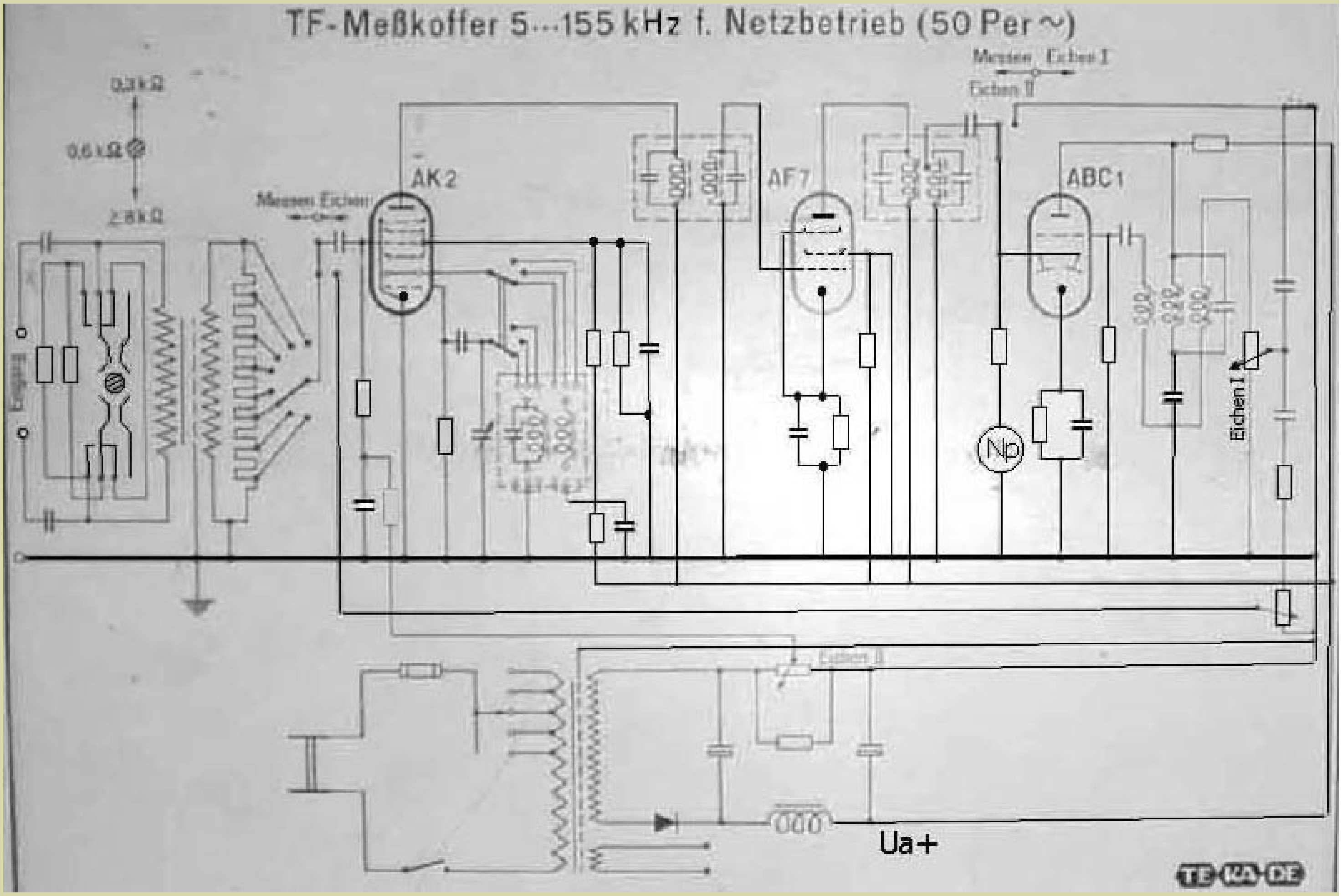
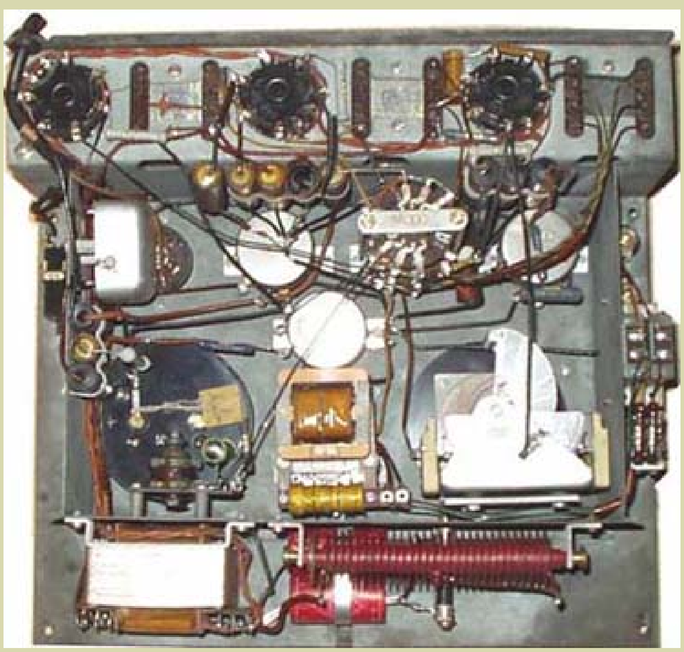
22.3)

TEKADE Träger-Frequenz Meßkoffer 5-155kHz (later German term is **Selektiver Pegelmesser**),
Suppose this is the first selective voltmeter ever made. They were used to measure levels on multi-channel carrier frequency systems. One such instrument were placed in Kristiansand, another in Arendal since it was subsea coaxial cables to Denmark, believe it was a 15-channel system (MG15) during the war and many years after.
See Die deutschen Funknachrichtenanlagen Band2 "Der Zweite Weltkrieg" pg139

See application on pg-33b, pg-k61 and pg-k62



TEKADE **Träger-Frequenz Meßkoffer** (Circuit diagram)



22.4)

Philips GM7633 Cartomatic III

Old tube testers and other instruments, see http://www.one-electron.com/FC_TestEquipment.html

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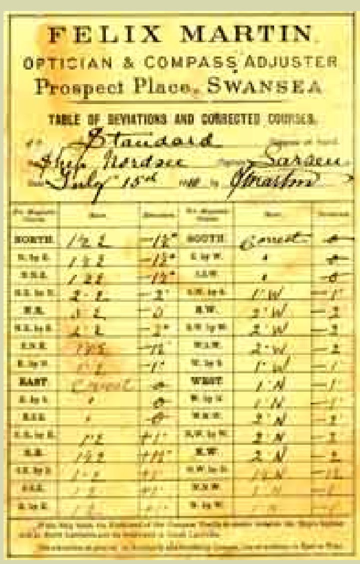
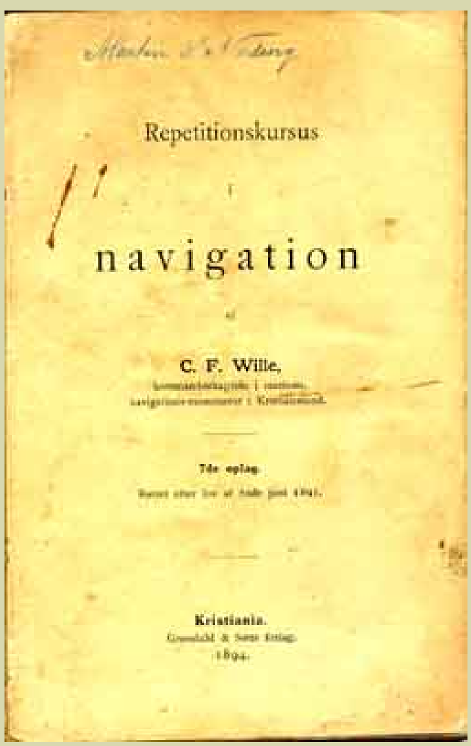
[Nolan Lee's site for tube testers]





Felix Martin, Optician & Compass adjuster, Prospect Place, Swansea
Repetition course in navigation 1894

BACK

Email: [redacted]

2004.09.24

LA8AK

m21 Norske instrumenter til elektronikk XXI
Norwegian instruments and techniques

Tritron Frekvensteller TS - 1003 Mk2 (600MHz), **TS-1004** (1000MHz) o.l.
LA4MH Henrik Lone har reparert endel av disse.

1) Generellt problem er 10-leders flatkabel til hovedkort som ligger for stramt og isolasjon for dårlig
2) Sjekk også flatkabel fra display
3) vakkel vender

Endel har elendig frekvensstabilitet, som kun passer til 2m FM, bruk av 10MHz TCXO kan forbedre dette

Monitorforsterker ab **EB**-fabrikat (tastafon multialarm, høyttalerenhet) er kjekk å ha til å lytte på forskjellige svake LF-signaler. Den anvender TBA820M, og må dempes ned en god del da den er altfor førsom, det er også koplet inn en seriemotstand med høyttaleren for ikke å sprenge IC'en ved kraftig overstyring.

XXI-II

Impedance Meter 252 (Amerikansk)
Måler kapasitet, induktans. Umulig å skaffe dokumentasjon for, og derfor vanskelig å få kalibrert

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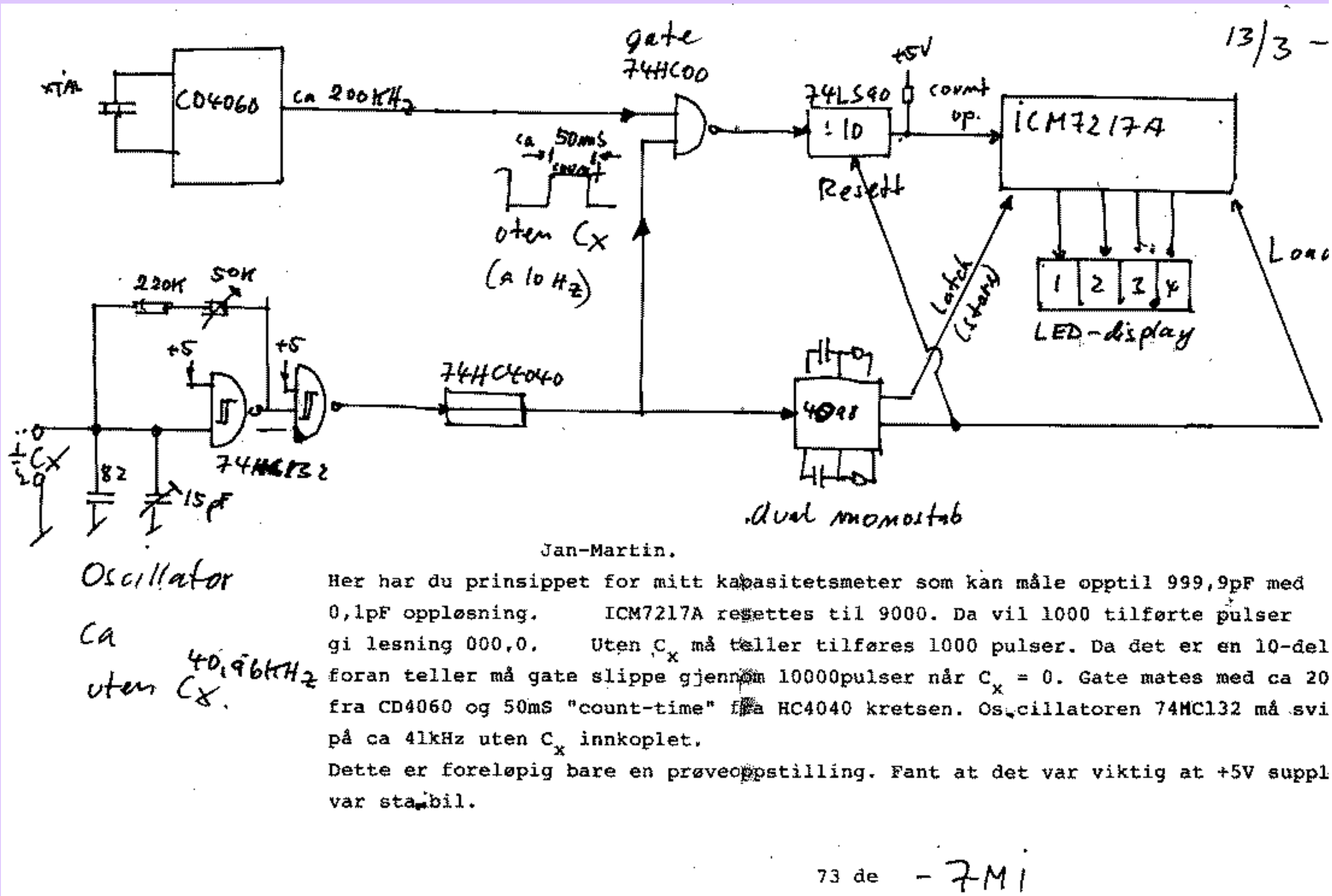


Jan-Martin.

Her har du prinsippet for mitt kapasitetsmeter som kan måle opptil 999,9pF med 0,1pF oppløsning. ICM7217A resettes til 9000. Da vil 1000 tilførte pulser gi lesning 000,0. Uten C_x må teller tilføres 1000 pulser. Da det er en 10-del foran teller må gate slippe gjennom 10000pulser når $C_x = 0$. Gate mates med ca 20 fra CD4060 og 50mS "count-time" fra HC4040 kretsen. Oscillatoren 74HC132 må svi på ca 41kHz uten C_x innkoplet.
Dette er foreløpig bare en prøveoppstilling. Fant at det var viktig at +5V suppl var stabil.

73 de -7MI

LA7MI's siste eksperiment gjelder modifikasjon av frekvensteller til å måle kapasitet.
LA7MI's last experiment is for modifying ICM7217A frequency counter to measure capacitance, it measures 0-999.9pF with 0.1pF accuracy. Just got his letter, no more info is available.

XXI-III

Transitions from BNC to conhex and vice-versa (**75Ω**)
Conhex is usually found in interconnections for AF, Baseband and 70MHz IF systems for radio links (NERA),
but has also been used for early 10GHz systems, probably 50 ohm systems (at least in Sweden)
Overganger fra BNC til Conhex.

Email: [redacted]

[BACK](#)

Edited: 2005.03.16

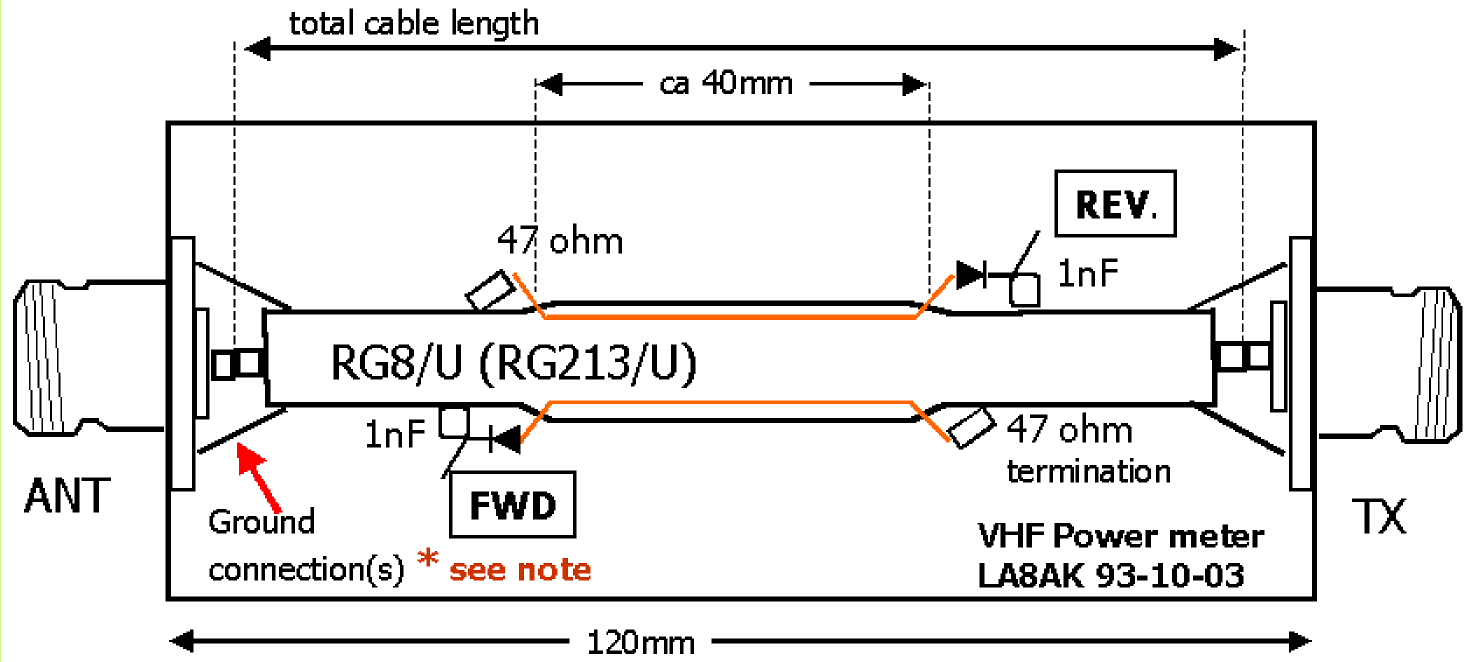
LA8AK

m12. RF power- and VSWR-meters

#12.1)

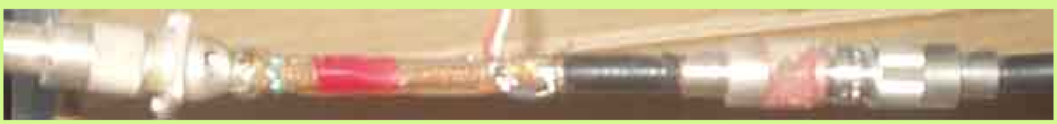
Some cheaper "SWR" meters. The Norwegian **Picomatch II** to the left is quite good instrument for 144MHz, believe it is specified quite strict, but some day the instrument people don't like any old instruments.......

The Inter-Power SWR-5 - upper right - "isn't worth a penny". Got it from a mate to use with a beacon, but I burnt it out with only 3.5-4W morse signal on 70cm. Removed the bridge and installed my own pick-up line (suggested by LA8OJ) and now it is fb for VHF/UHF. The old **Hansen, Reace or whatever** make "SWR-meter from 1968 (from J. B. Lowe) or later has a relatively good bridge, it works fb on 2m - provided careful operation, sensitivity is very good on 2m! It is easy to destroy, but works fb with level down to 10mW, have used it on 180-190MHz to test TV-receiver antennas using Wavetek Model 3001 signal generator, but mounted N-connectors to make it look sufficient professional at work, see next note.



The **Inter-Power SWR5** was renovated and since the meter and box was so nice looking I decided to keep it and remove the useless bridge. Mounting wire is pulled under the braid for a length of 40mm. It is easier for the old type RG8/U, where the braid often is somewhat looser than for RG213/U. I wouldn't think about using RG214/U! It was some struggle to mount the bridge, and solder in the right order since it is just as must space as you need.
NOTE* Ground connections from braid to coax connectors should be the last mechanical step to do.

#12.2)



Another application of the same technique. It is so easy to build pick-up bridges, it is just fun.
Here is my 2m line - permanently inserted between the PA to antenna.
Suppose RG8/U type coax-cable is better than RG213/U since the braid may be somewhat loose, but must not be dark and corroded.

#12.3)

The **old single-small-instrument SWR-meters** are not much good when using an antenna tuner (see first picture), but addition of two external meters is a vaste improvement, so i fitted two phono connectors on the old small SWR-meter, to 2 external meters with potmeter on an aluminium plate, and hide the old instrument somewhere in the back of the shelf.

Just add two coax-connectors and hide the old coupler somewhere in the background and you don't need to see it any more. My main HF operation has been with 100W output on 80 and 40m cw and the coupler (SWR-meter) is good enough for use with an antenna tuner.

#12.4)

My own directional coupler for HF - made as an alternative to the old VSWR-meter mentioned above. It is sort of amateur 'design', you know when it is not possible to make to equal units, forgot which handbook I found it, but it works good enough for my desires, and when you are an electronics engineer with laborating background you know what is important or not, this is good enough for me! It was wired in an afternoon and I don't want to waste more time on a simple project - at least unless I didn't find a reliable construction.

#12.5)

Oskerblock. May select between 50 and 75 ohm line. Probably not the most accurate instrument to have in the shack, but I never really bothered. With some years of experience one understand that it is not important whether the power is 80 or 100W, and I could always use the Bird model 43, but really, it is just not important. Accuracy is for those who don't know, and not important for electronic engineers like me - in
my own home!

#12.6) VHF power-/VSWR-meter

Another 2m power meter I built. Wished to see what sensitivity could be achieved with an extra LM358 op-amp, so the sensistivity for FSD is only 80mW. When you know that the connectors are BNC-type, you'll understand that the coupling loop is quite small. The probes consist of insulated pvc wire under the braid, terminated with a germanium diode in one end and 50Ω in the opposite end.

#12.7)

More power ranges with Bird Model 43.

Model 43 RF wattmeter is too expensive to buy for experimenters. Got mine in 78 - in the darkest socialist ages - when it was good tactic to overprice items provided they paid sufficient taxes, and VAT was higher and the social democratic government very pleased. Got a 1W 150MHz surplus probe - very useful to measure 2m exciter power levels. Per, **OZ1CFO** found a 2GHz probe at an army surplus shop (Midtjydsk reservedelslager, Viborg).
Have heard of other types, too, so you may find odd types elements which is not described in any available documents.

Morgan, **SM6ESG** discovered a trick where you just pulled the probe and found a stable position where the sensitivity was reduced 6dB.

A trick is to remove the plastic cover on the probe by pressing the sides and lurking very carefully with a screwdriver to push the cover away. There are some screws under the type label, but you won't get anywhere into the element by removing the label (according to Henrik, **LA4MH**)

It is quite easy to find the patent description for **Bird Model 43** on http://ep.espacenet.com/ and write "Directional wattmeter" as search word. You'll have two hits, then choose "**US2852741**", then there is a page where you click on the patent - coloured ink in middle of the page, choose 1/16, 2/16 to read the different pages
.

A way to store the wattmeter probes on the side of a shelf

It would be insteresting to see if the circuit is patented and if it was possible to find it, we found the Bird Model 43 documents quite easily.

click on <http://ep.espacenet.com/> and write (copy) into searchword "Directional wattmeter". You get two hits, then clikk on "US2852741" for Bird Model 43, then it is a page where you click on the patent - coloured ink in middle of the page, choose 1/16, 2/16 to read the different pages

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#12.8) R&S VHF surplus RF power meter (VSWR-meter)

A **Rohde&Schwartz** instrument of the higher price class, but unknown model. It has been used for broadcast transponders where high quality is demanded, but prices doesn't matter. Got for free since the fool at the surplus shop laughed at me and thought that nobody needed an instrument for 88MHz.
Have only tested it for 2m, the only problem is to calibrate i, but calibration is usually not important.. Would believe it is likely

the probes may be adjusted for proper operation on UHF as well as VHF.

Inside view of the **R/S VHF power meter**. The coupler probes may be adjusted for almot any degree you may desire. Suppose it is not such thing as power limit for this coupler. It was easy to convert the dezifix connectors to 83'type (SO239). Found similar probes in some other equipment.

#12.9)

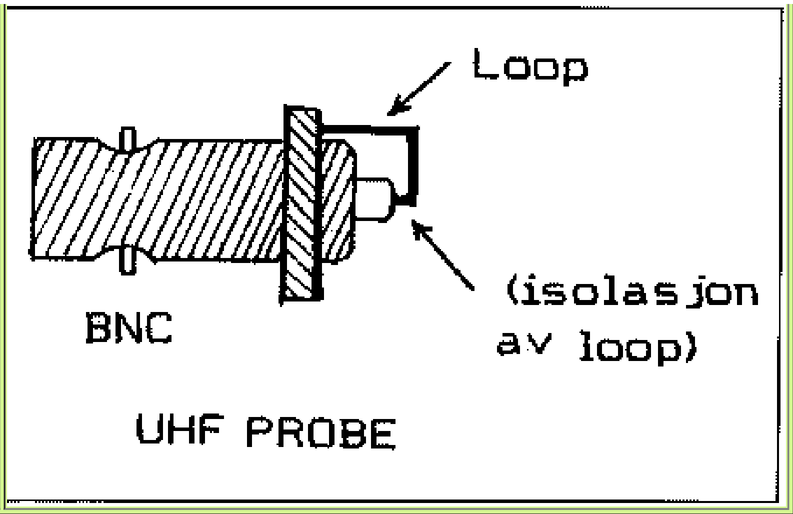
R&S surplus UHF power meter NAD.

Rohde & Schwartz NAD (470-2800MHz) with couplers for 10W and 1000W.
Had it calibrated 10 years ago. Only problem is dezi-fix connectors, but fortunately got transitions for the larger type.

#12.10)

VSWR coupler from discarded 900MHz mobile telephone base station

LME coupler for NMT900 system



#12.11. It is important to have available an RF pick-up tool as shown for RF level meters and frequency counters, it will work over the frequency range 10-500MHz, and may also be used to inject signal from a generator to RF coils when the receiver seem death.
Above 1000MHz with strip-line this is not effective, the coupler should be plane as shown in the second figure, but it is important to remember insulation for the pick-up wire.

Some German coax connectors of the 50...60's.

Above is the coax connector usually found on CF instruments from Wandel&Goltermann and Siemens, and below is the Fernsehen connector which is practical for video switch panels. I use them for selecting between HF antennas. (Also shown on page m1)

Email: [redacted] e/m

[BACK]

2004.10.07

LA8AK

M2 RF detectors, level meters, attenuators, RF termination (dummy loads),signal dividers

#2.1) Surplus attenuators

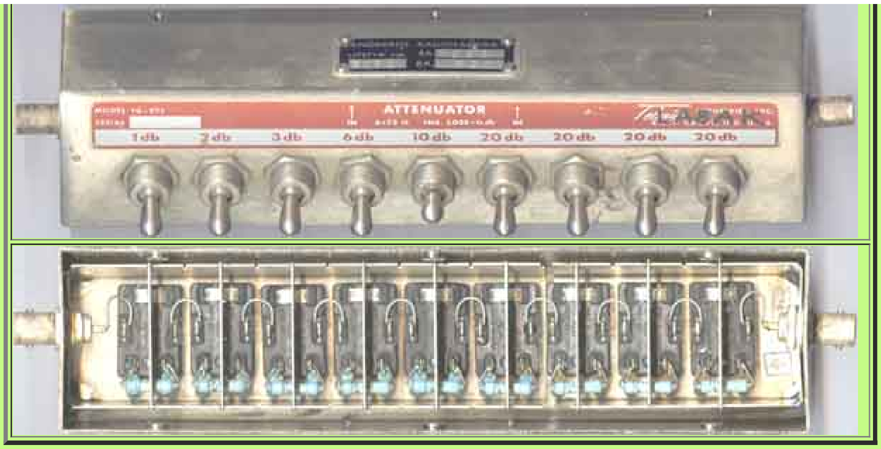
Muirhead & Co No. 355748, it has 0-61.5dB in 0.5dB steps (75 ohm).

Problem with attenuators is that when you need them, you can't find sufficient amount of them. I've often needed 3 for some experiments, and 75ohm attenuators in a 50 ohm system does not cause much inaccuracies, so when you have checked it and are aware of the possible problems you just don't care so much.

Another argument is that I use a lot of available cables and equipment from work which are made for 75ohm systems, and it saves me a lot of trouble to use what is around instead of buying what you really don't need.

Inside look of the Muirhead 75Ω attenuator (boatanchor). It is well screened between the sections, but isn't much looking like an instrument for VHF, on the other hand it seems to be good - at least for the lower part of VHF range. It came with some Marelli radio link equipment and I had to change the connectors to BNC. Have passed some to other amateur radio experimenter and they are quite satisfied with using them for 50Ω. But again you need to be an electronics engineer - with 30 years experience to understand how easy it is!

#2.2) Telonic Model TG-975 (First owner: Tandbergs Radiofabrikk, year: 1965)



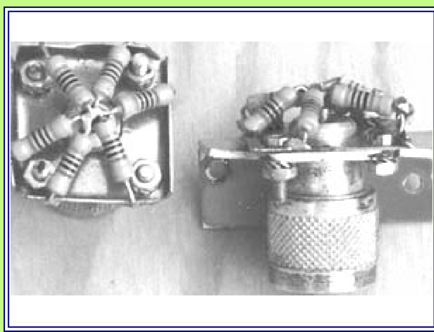
Another 75Ω (0-102dB) attenuator I bought in 1980 because it looks so easy to repair. Has used it on VHF and 70cm (50Ω), when you are aware of it it is only marginal difference between a 50ohm and 75ohm instrument. The switches are mounted between the different rooms with the resistor through holes.

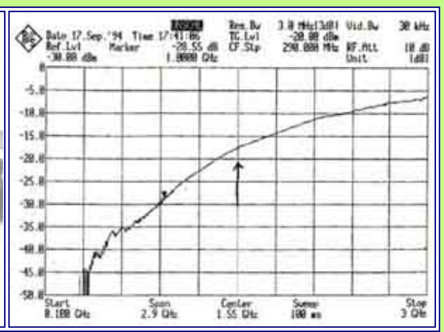
#2.3) **Danbridge Decade Attenuator type DA3HS/D**; 600Ω, 0-111dB in 0.1dB steps.

Decade resistors and decade attenuators are among those items I regard as waste or time and money, but I got it from work, and have never used it, or missed it. Such things are usually believed to have a value by persons who don't understand much. I wouldn't use a decade restance unit to find a resistor value! This unit is better for next junk-sale.

(S.: atenaters)

#2.4) Practical VHF/UHF Dummyload to build



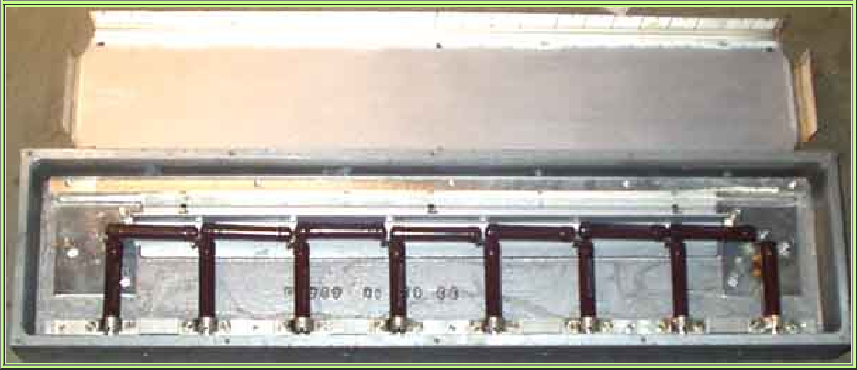


Building termination with standard components is easier than people think!
But, usually experience is better than thinking.

Practical dummy-loads mounted on N-connectors. Using male connector it can be connected directly on the Bird Model 43 wattmeter. it uses 6x 300W 1W Draloric LCA0414 carbon resistors. To ease soldering a timmed iron plate is attached to the connector first.

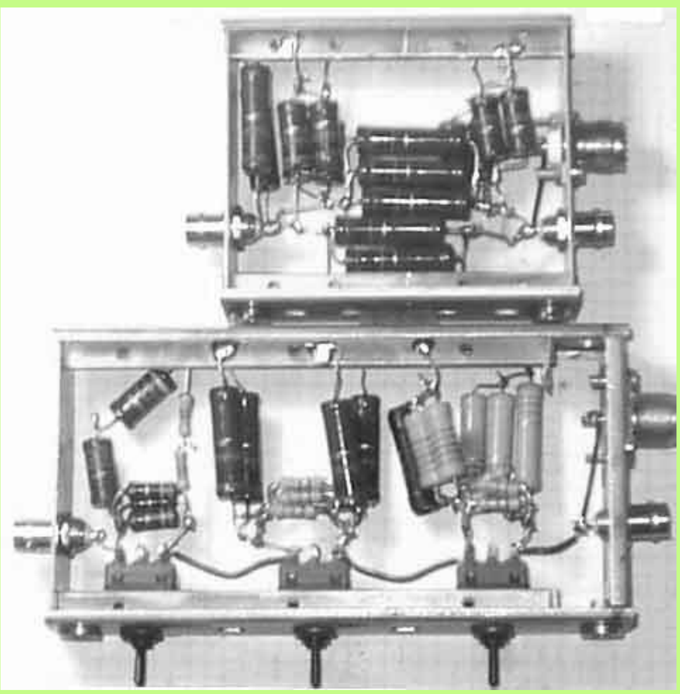
The Rohde&Schwartz team offered to measure it at a their stand at the Weinheim UKW Tagung, the one with male connector has almost **20dB return loss at 1300MHz**, - not bad for standard type carbon resistors! Only had one available.

#2.5) Power Attenuator (25W 30dB)



Rohde&Schwarts RBD 600MHz 30dB attenuator uses discrete power resistors, note the frequency limit, it is professional equipment! The attenuator is original 60 ohm, so I have modified it with some extra resistors to 50 ohm. The original Dezi-fix connectors were easily changed to BNC.

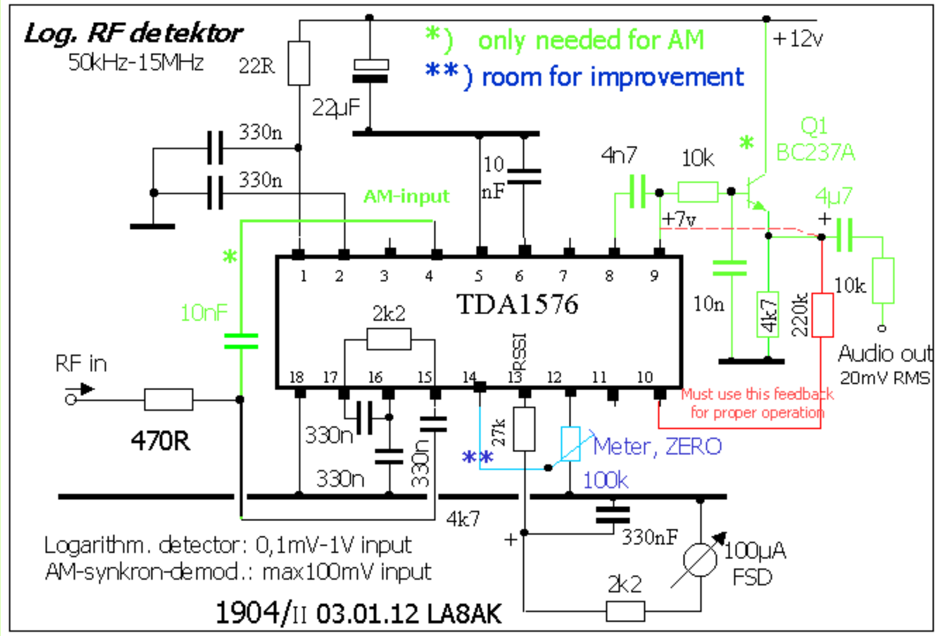
#2.6) more power attenuators



Some power attenuators used for experiments on HF

High-level PIN-diode attenuators, see page c11

#2.7 RF Level meter using Philips TDA1576



10a) TDA1576 (Philips) as level meter, has 70dB range. But using the internal meter offset adjustment circuit upset the range, so it seems better to use an outside circuit. Also useful as quasi-synchronous quadrature AM-demodulator, but it is overloaded with larger than 100mV input.

Bird's nest using TDA1576 as a general purpose detector for 10kHz-15MHz

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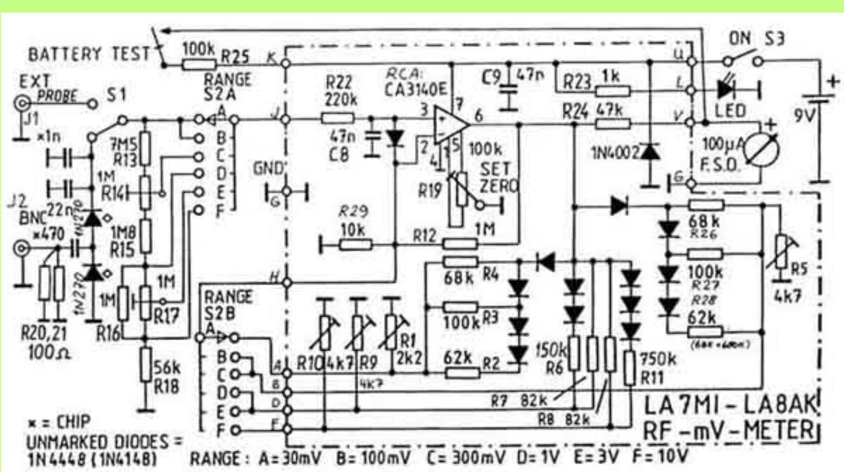
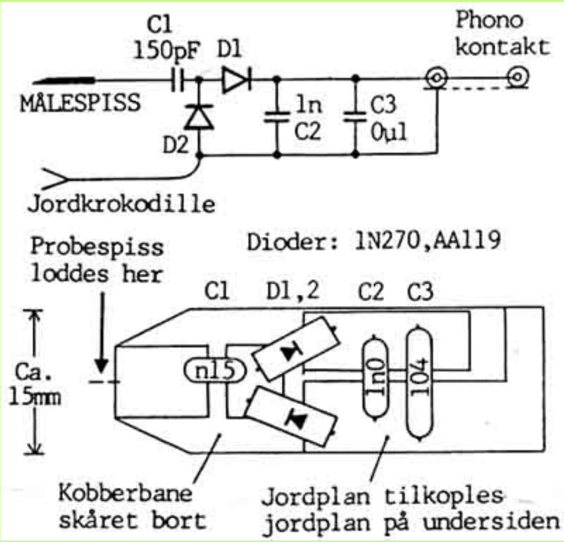


#2.8 LA7MI linear scale RF-mV meter for 0.01-1500MHz.

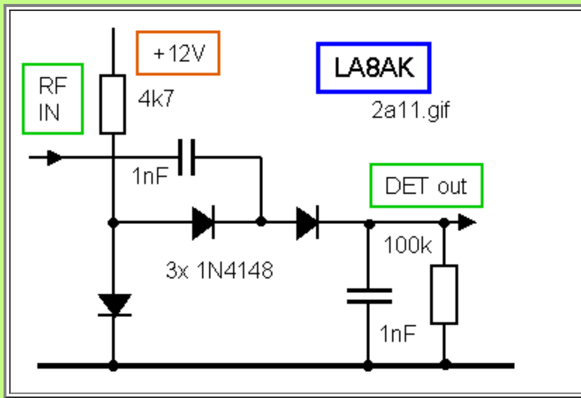
Believe it measured better than 10% accuracy to a linear scale on all ranges except the lowest (30mV) up to 500MHz. It was not intended to by LA7MI to have this range since strong transmitters in the neighbourhood gave over 30mV deflection with the high impedance probe, but I added it in my version since I mainly measure 50 ohm circuits via coax cable, and only very seldom use a high impedance probe. Also used it with small coax loop to align local osc for 2320MHz

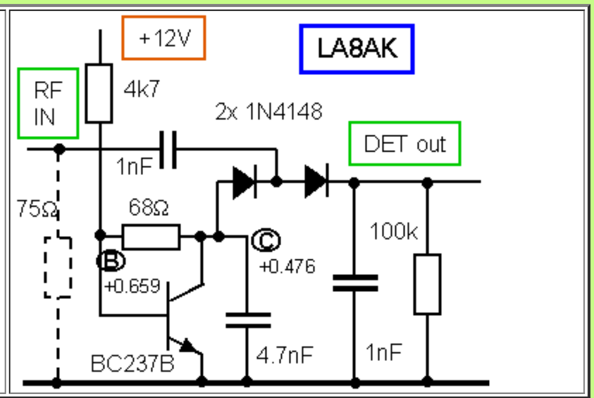
transverter.



RF probe for RF mV-meter. Ground on two-sided PCB laminate component side is connected to the screen side below.
The board patterns is fabricated using hacksaw. The construction is so self evident that I believe you don't need to have the words translated, it was only a point in the first amateur radio magazine it was presented, and as such not shown in DUBUS.
jordplan=groundplane, probespiss loddes her =probe tip soldered here, jordkrokodille = crocodile clip to ground.

See also the other alternative instrument described below.





#2.9) RF detectors using 1N4148 type silicon diodes.

An extra diode is used to forward bias the detector. It has relatively low impedance and decoupling is not usually necessary. Using a transistor instead of the diode it is easier to optimize the forward bias voltage, but the voltage drop over the diode is current dependent, and still with 250mV forward drop it draws some current. Another problem is temperature stability.

Supply voltage	Base voltage	Collector voltage	DC output voltage
9v	643	518mV	44
12v	659	476	34
15v	649mV	438mV	26

It is important that the supply voltage is stable to use the circuit shown above

RF input (450kHz) RMS	Detector output (2nd circuit)
--	+30mV
25mV	+33mV
80mV	+58mV
250mV	+300mV
400mV	+625mV
800mV	1.568V

The detector is not linear, but may be useful for several non-accurate purposes

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c42 Variable bandwidth xtal filter with constant gain using negative impedance amplifier - (a technique used in HP141 and similar instruments)

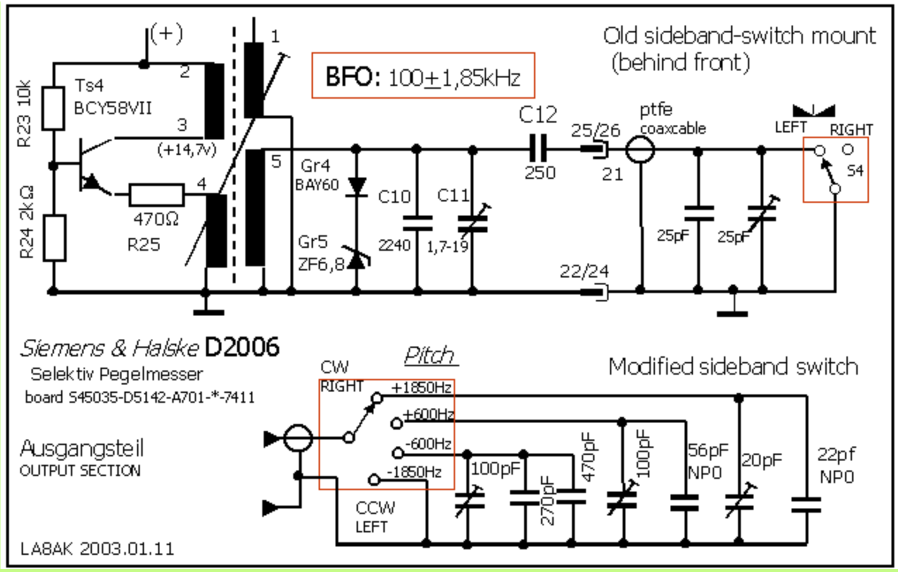
#2.10) **Very old LF selective level meter** (Messkoffer)

TEKADE Träger-Frequenz Meßkoffer 5-155kHz (later German term is Selektiver Pegelmesser), Suppose this is the first selective voltmeter ever made. They were used to measure levels on multi-channel carrier frequency systems. One such instrument were placed in Kristiansand, another in Arendal since it was subsea coaxial cables to Denmark, believe it was 8 or 15-channel systems (ME8 & MG15) during the war and many years after. See Die deutschen Funknachrichtenanlagen Band2 "Der Zweite Weltkrieg" pg139

See chapter M22 for more info about old instruments.

#2.11) Siemens D2006 Selective level meter (Selektiver Pegelmesser)

The advantage with this instrument is that it is still easy to repair and modify.



Sidetone modification.

The problem with many of those Selective Level meters is that the pitch is meant for somebody else, but not hams.
It is far too high for CW reception, for this unit it is 1.5kHz (some other instruments may have 1850Hz). So you cannot use the lowest bandwidth to listen to a CW station, only for measurements, and must tune to lower pitch using wider bandwidth. When I listened to SAQ on 17.2kHz (Alexandersson Generator) last summer, the signal to noise was only 6dB or less, but I later discovered that it was some strong noise sources
just above this frequency, and if I could use the 80Hz bandwidth it would improve 30dB. It was therefore a good idea to open the handbook and start interpreting the German text. Soon it was discovered the solution here is quite simple, all the modifications are made behind the front plate, none on the actual board, you remove some components and install a swith with at least 4 posititions and a small board for trimmer capacitors with some fixed values in parallel. It was difficult - even when reading the book, to understand the proper way to open the instrument. Was it neccessary to take off the front? Yes, it was, and it seemed rather difficult first, but wasn't so difficult, when you learned about it, and I needed to remove it later, because I forgot some screws.....

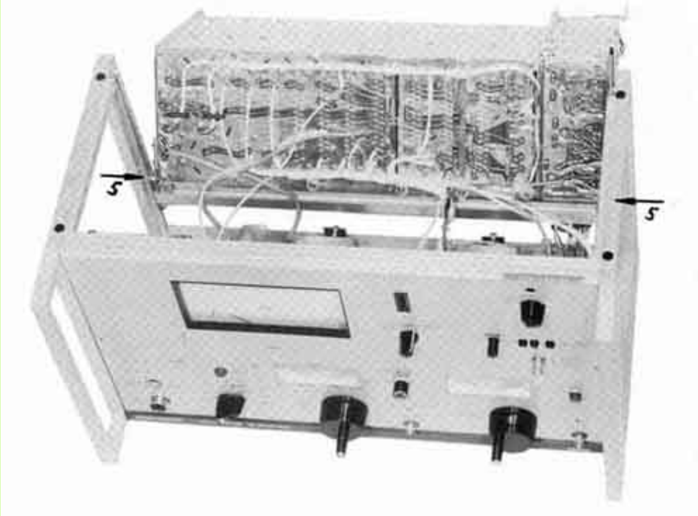
The board **S45035-D5142**-..(Ausgangsteil) has a simple product detector and BFO. The BFO frequency is tuned with 2250pF and it is shifted by S4, possibly shifting it 1.85 below and above 100kHz as the switch is set to left or right. when the 250pF is grounded it is LOW and when it has the external capacitors in series it is HIGH. The unmarked capacitors above the switch behind the front are 25pF styroflex and 25pf air trimmer, I measured 41pF, but don't always rely on the instrument, and to this figure you must add some 50pF for the PTFE-cable.
Remove all plates and screws and when you still can't find a way to get into the box, you must start reading the instruction book, Chapter 4, MAINTENANCE - only to discover that you can just as well put back some of the screws again and remove the upper unbrako type screws instead - to slide the upper unit backwards. It was a fight to remove the front plate, but it went after all. Careful with all those terribly small 2.5mm screws, nuts and washers!

Considered using varicap diode (BB112 or BB130), but it must be shorted for USB, it demanded a potmeter with an Normally-Open-switch and they are rare, so I decided use a switch with 4 positions instead.

Connected 3 trimmers and fixed value capacitors on a bracket with pcb laminate where the old capacitors had been.
The 4 positions are now:
1. Shorted coax cable as earlier CCW with 1850Hz pitch for 80Hz filter.
2. 470pf+270pf + 100pf trimmer - to tune one sideband with 500-800Hz pitch
3. 56pf + 100pF trimmer, to tune the opposite sideband with 500-800Hz pitch
4. 22pF + 20pf trimmer (or 10pf fixed and 40pf trimmer) for CW as before

used a six position switch, but couldn't think of the need to use more than 4 positions, didn't find any small swiches with long shaft, so the nut must protrude through the front plate, so the hole must be widened a little for the nut.

The audio output level is high enought to drive a 300ohm dynamic phone inset (+1dBm or 700mV)



Anweisung: Schrauben 1, 2, 3 und 4 lösen, Baugruppenwanne um Drehpunkt 5 kippen.

Servicing Siemens D2006 Level Meter, when you have unscrewed the proper screws amongst the many which seem much more likely to choose...

#2.12)

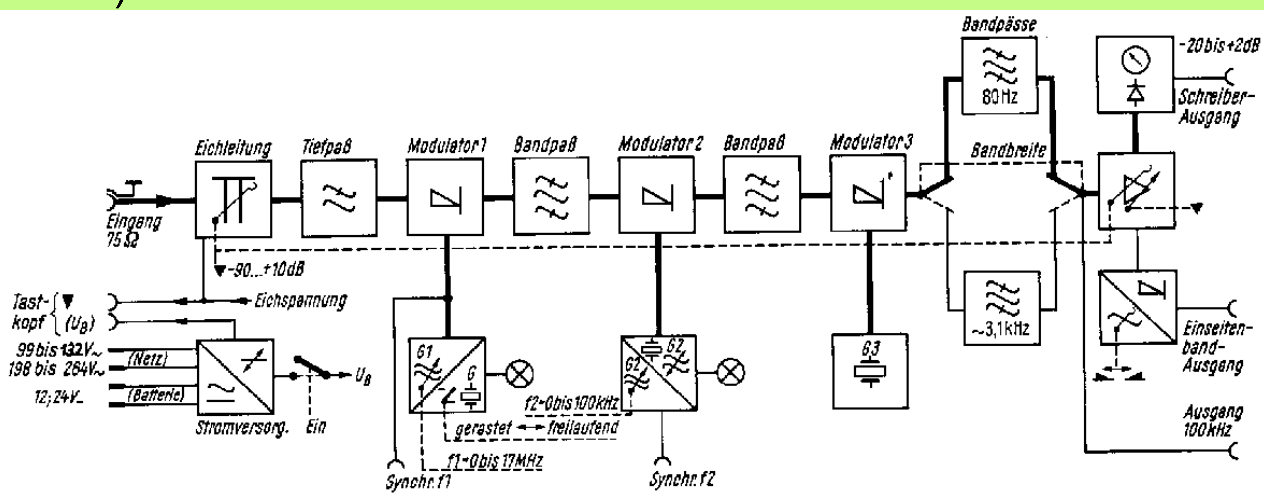
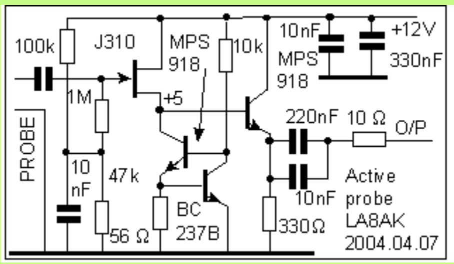


Bild 2 Übersichts-Blockschaltbild des Pegelmessers D2006

Siemens D2006 Level Meter.
Block circuit

#2.13) Active hi-Z RF probe for use with D2006 or other instrument

The probe under check connected to Siemens D2006 selective level meter (or other similar instrument)

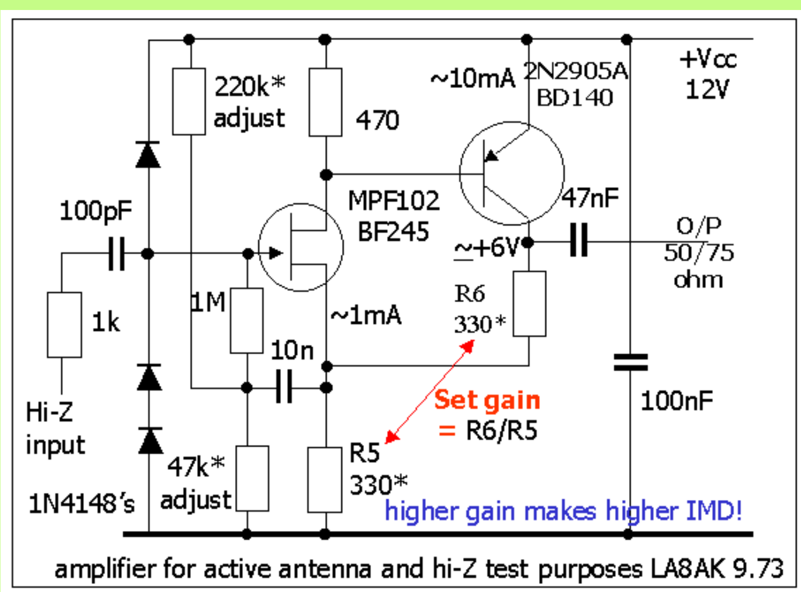


Circuit diagram for the probe. 1dB variation 50kHz-18MHz using Siemens D2006 Level meter (75 ohm), probe voltage loss: ca 1.5dB. The input coupling-capacitor is 100pF.

An alternative is the Maxim MAX4005 with frequency limit of 950MHz, but I needed the circuit today and don't want to wait for something I am not really sure if could find or how long it takes to get it. This device requires +/-5V supply.

[>.905. see block diagram for D2006 Pegelmesser (too large to display on this page)]

#2.14)



General purpose high input impedance amplifier was designed by LA7MI in 1973 for use as active antenna. It is important not to use more gain than neccessary, also the positive feedback to the input, should be done with care, and avoided if not definitively neccessary. We used it for a while, but I had some intermodulation problems with a local BC-station, it was later used with a general coverage frame antenna covering 0.5-4MHz without any problems. It is a simple circuit for some test purposes

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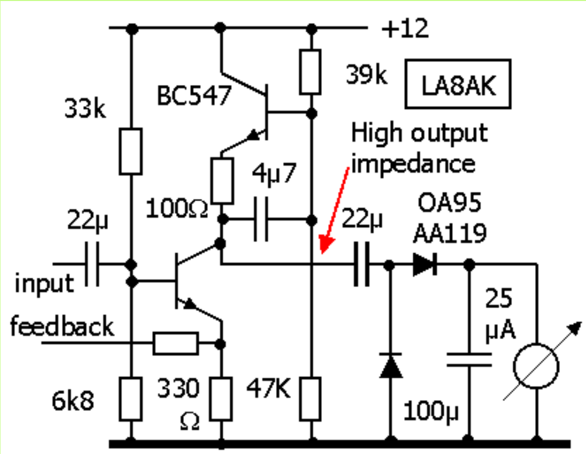
#2.15)

Linear RF detector

I've wondered what is the important rules to make a linear detector with conventional technique and germanium diodes It is described in Wandel&Goltermann SPM-3. The upper transistor operates as constant current source and at the same time balances the collector voltage for the first stage.



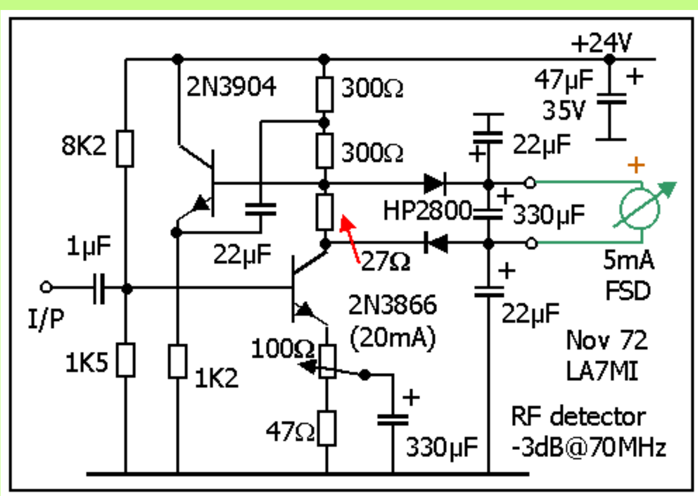
RF detector used in SPM-3 (Selektiver Pegelmesser)

SPM-3 (Wandel&Goltermann) is probably one of the most popular portable "Selektiver Pegelmesser/Selective Level Meter", it covers 0.5-612kHz and it is ideal for 136kHz measurements, it has built in chargeable batteries for portable operation (but they are most likely defective).
It is a matching signal generator - PS-3 - which may be controlled by SPM-3 for tracking on the same frequency.

#2.16)

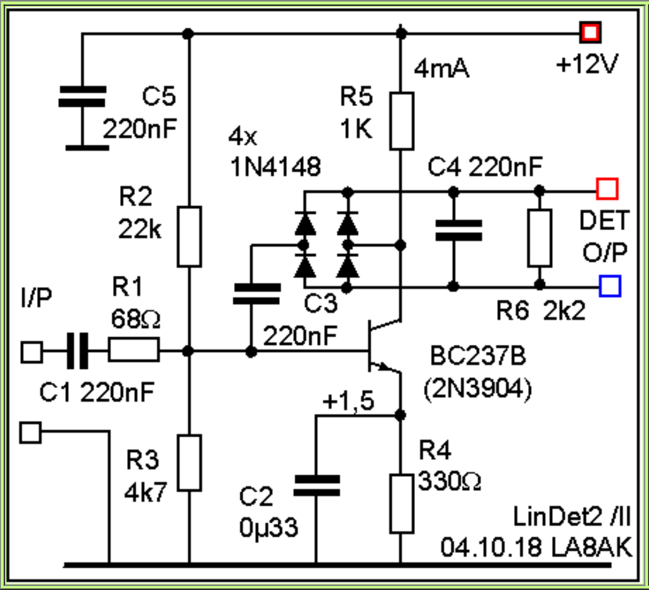
RF detector.

This is based on techniques found in HP-651B, but increasing the current through 2N3866 (BFR96) to 20mA LA7MI discovered that the frequency limit increases, -3dB limit was measured to 70MHz, it was used in his broadband RF millivoltmeter, constructed in November 72 - covering 360Hz-36MHx with 0.7dB variations. I is of course an old design, but sometimes once may still find such circuits useful, it is several other devices which simplifies operation like NE/SA604/614, TDA1576 etc.



HP651B detector circuit

#2.17)



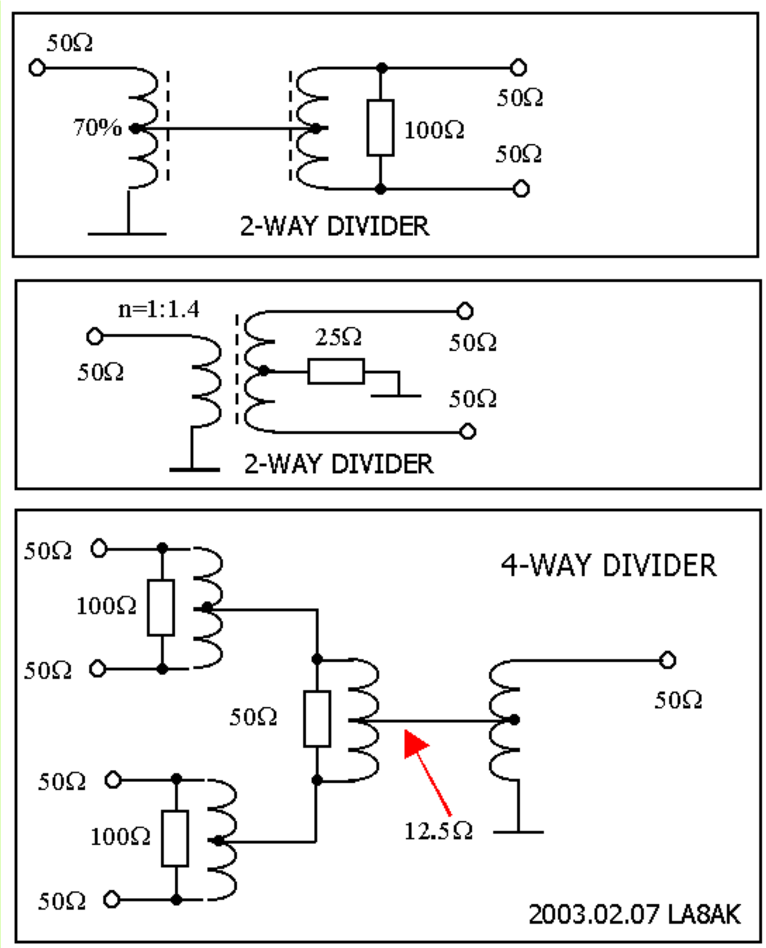
Another linear detector which isn't so critical for matched diodes, almost any smallsignal silicon diodes may work has been tested in the range 50-5000kHz, but I am not quite certain about all the critical factors.

Level.	-10dBm	-20dBm
50kHz	2.0	0.608V
190	2.05	0.654V
300	2.05	0.657
490kc	2.05V	0.660

Measured with WG PS-3 and Fluke 8020B DVM

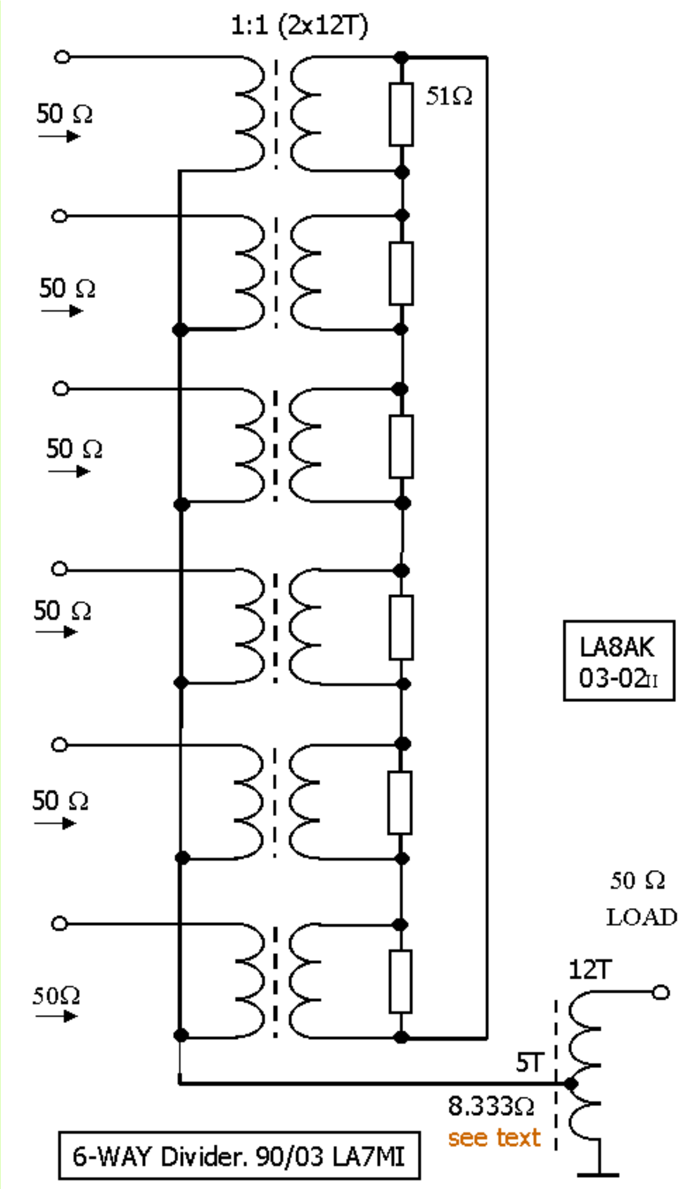
The detector may well be connected to a 1mA FSD 2kΩ meter

#2.18)

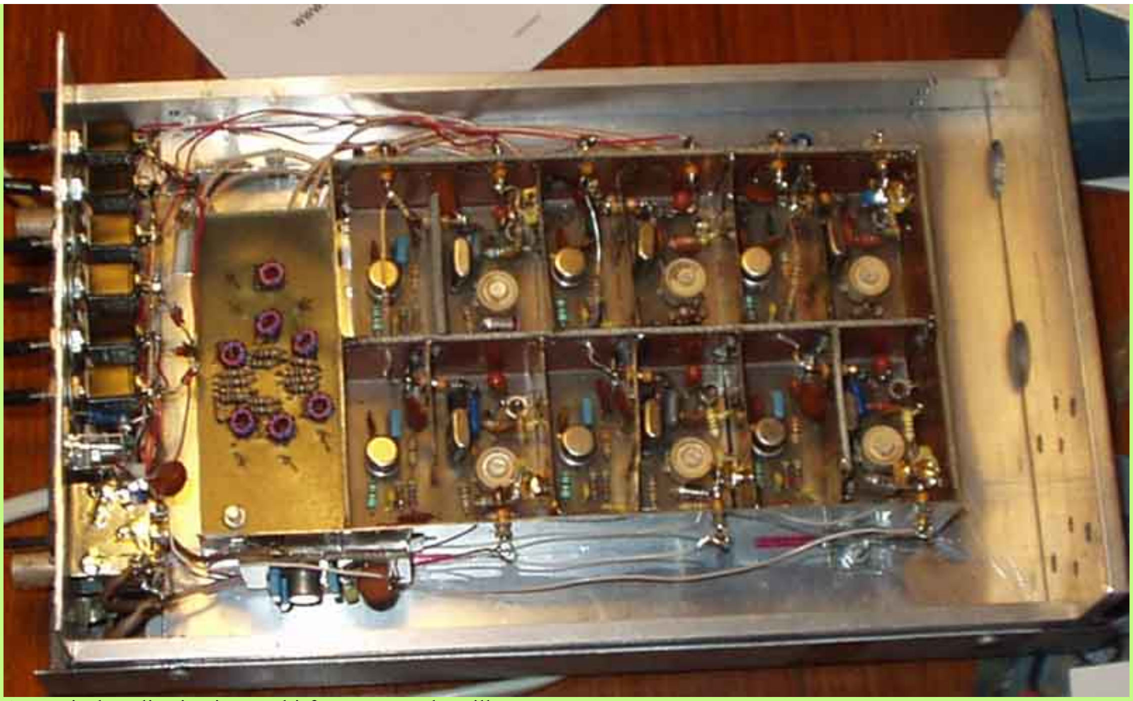


2-way divider (LA7MI)

#2.19)



6-way divider (LA7MI)



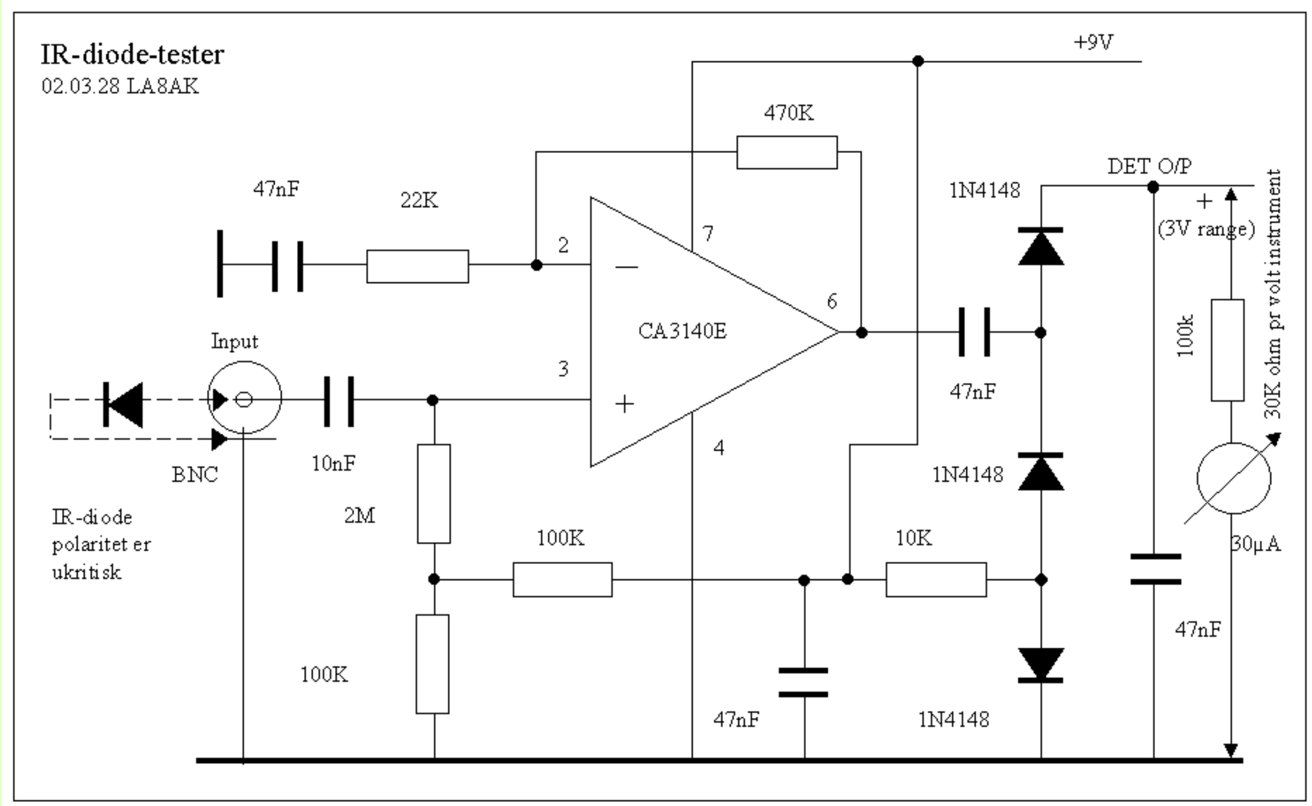
A practical application in a multi-frequency xtal oscillator

Power dividers: See 32. Weinheimer UKW Tagung, Scriptum der Vorträge 1987:
Leistungsteiler für VHF/SHF (DJ1EE):
1) Hybride Leistungstrafos, breitbandig KW-UHF
2) 3dB Richtkoppler (Koaxial bzw. Streifenleitungstechnik)
3) 3dB Branchkoppler (Planarer Streifenleitungstechnik)
4) Mehrwege- Wilkinsonteilr (Planare Streifenleitungstechnik)
Leistungsteiler/Addierer nach Wilkinson, Spannungsverstärkung der Einzelverstärker,
Breitband-Wilkinsonteiler (144-432MHz)

Booster amplifiers, see page-L2 or c14

#2.20)

It was a problem to find 2m signal generator with sufficient stability for ssb/cw 25 years ago, while an RF generator was easier to get. Here is my up-converter using SBL1/SRA1. The oscillator with 43.333Mhz xtal produces 130MHz to mix with 14MHz from the generator, to give a signal on 144MHz. The mixer has 7dB loss. To make it easy, I added attenuator on the input and output for total 20dB lower level than the level generator has. To convert from dBU (600 ohm reference level, 0.775V = 0dB) to dBm (50Ω) you must add an attenuator of 10*log (R1/R2), where R1=600Ω. And if the generator has 75ohm impedance you could use a minimum-loss-pad.



IR test receiver - to test IR transmit diodes, any IR diode will work, I used a transmit diode for my receiver

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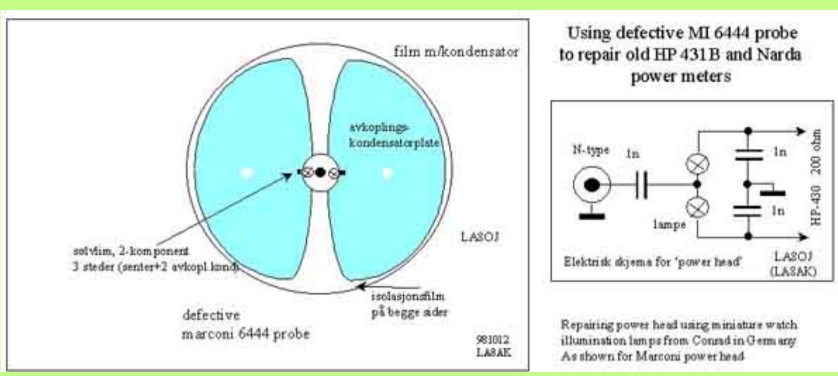
#2.21)



LA8OJ used defective MI SHF power meter heads to make his own probes for NARDA microwattmeter using subminiature lamps

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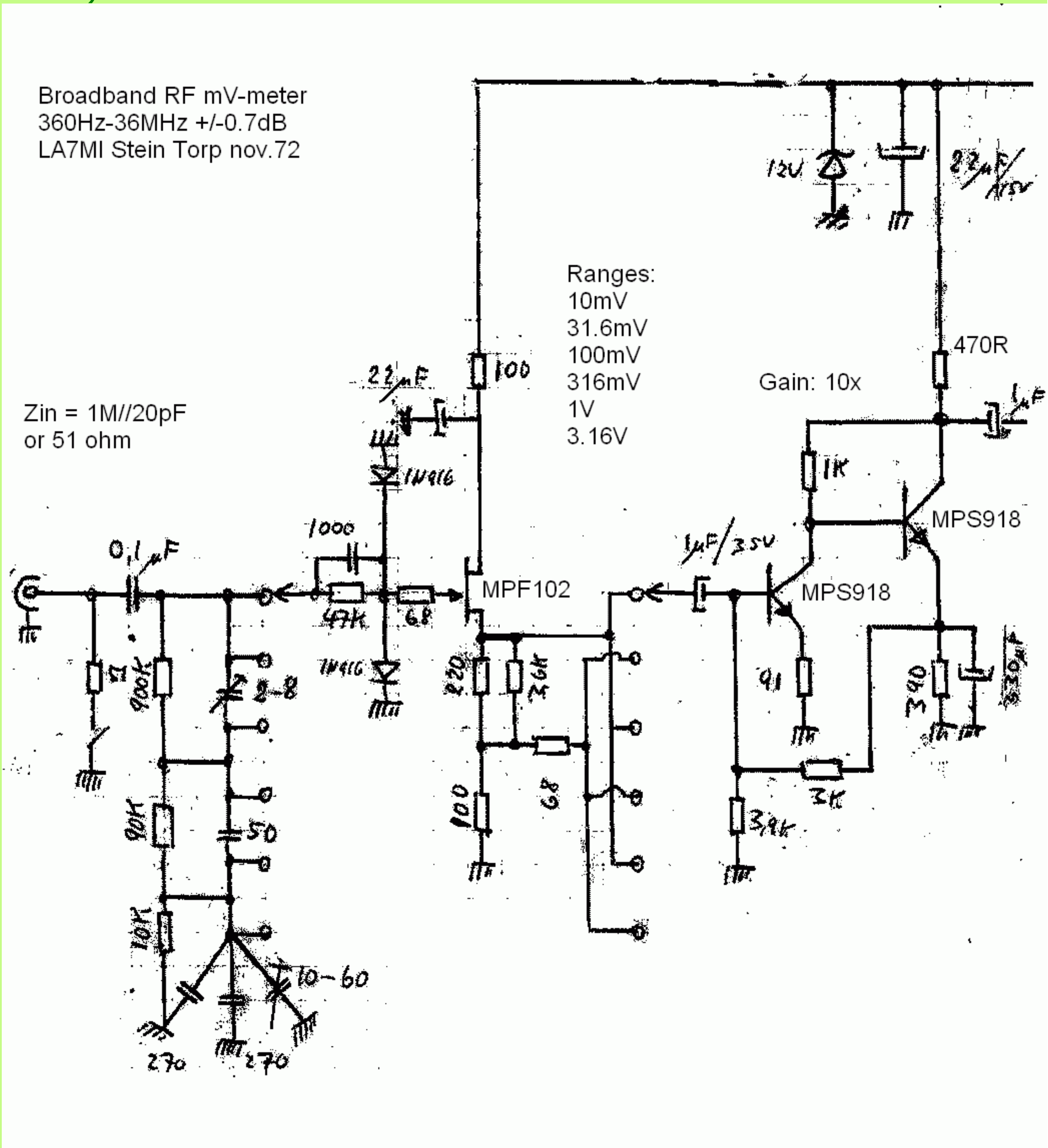
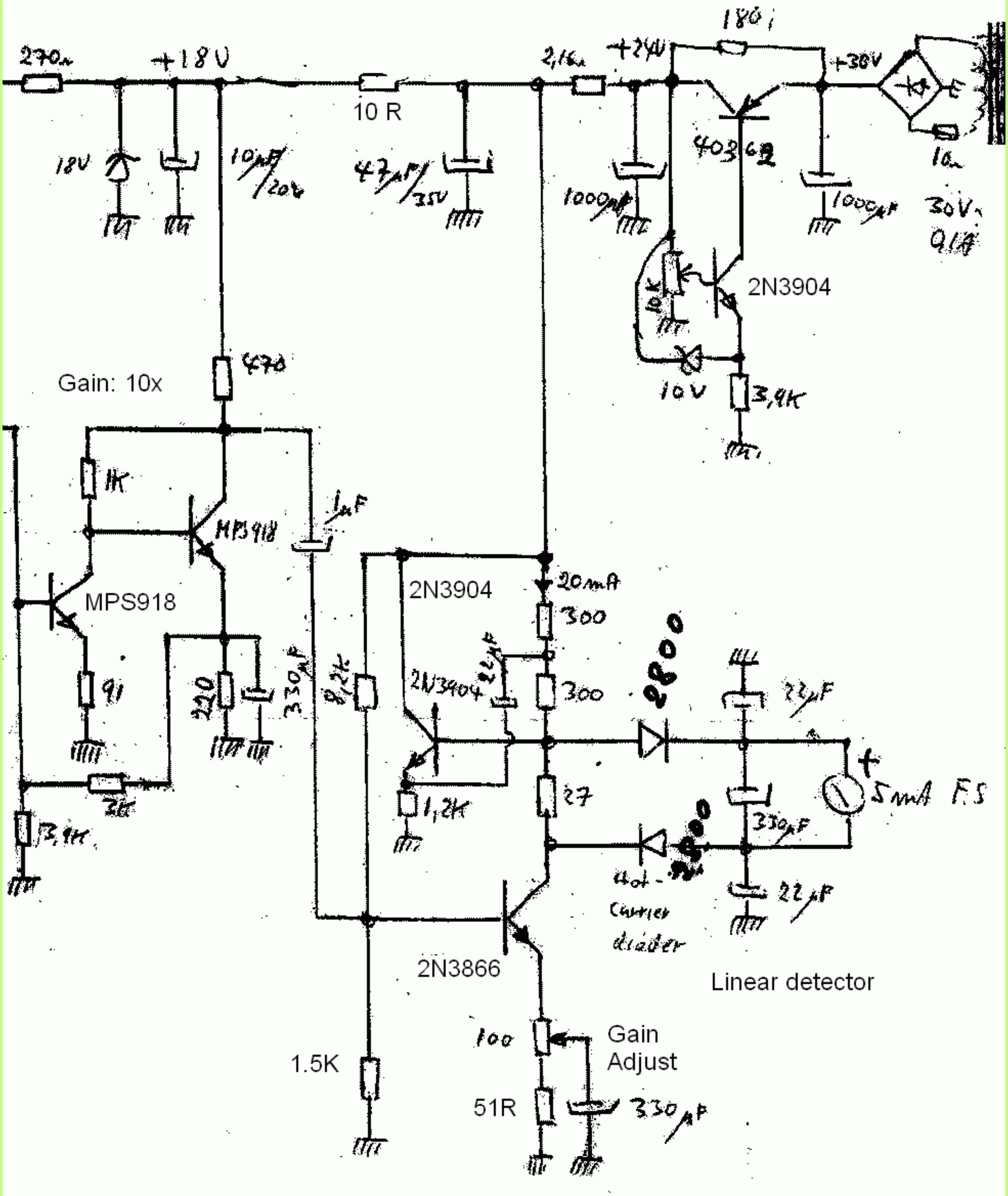
#2.22) LA7MI 360Hz-36MHz broadband level meter.

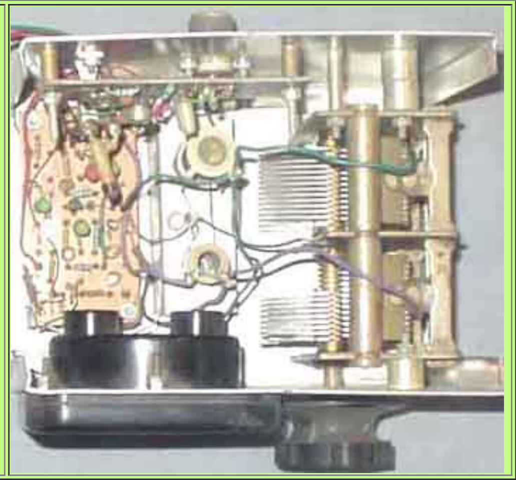


LA7MI linear broadband RF mV-meter (Circuit diagram Part 1)



Part 2. Linear RF mV-meter
Some "Pegelmessers" have a selection for broadband, this is useful for several measurements, but usually this is only available for instruments covering up to 600kHz. Here is shown a broadband level meter covering from audio to 36MHz, and with some inaccuracies further up.
Many IC's are available for RF detectors, but they are not linear. A linear instrument has apprx 20dB ranges, but 10dB covers most of the scale.
Believe the circuit diagram of the RF detector was found in HP651 signal generator, but it was improved with higher current.
The rectifier delivers 30V DC

#2.23) *'Selective'* RF level meter



"Selective" RF voltmeter for HF (two ranges) built in 1982 (described in Radcom)

N2PK's Amateur Radio Projects Page

[Vector Network Analyzer (VNA)]()

[Nolan Lee's site for tube testers]()

Old instruments and tube testers, see [http://www.one-electron.com/FC_TestEquipment.html]()

Email: [redacted]

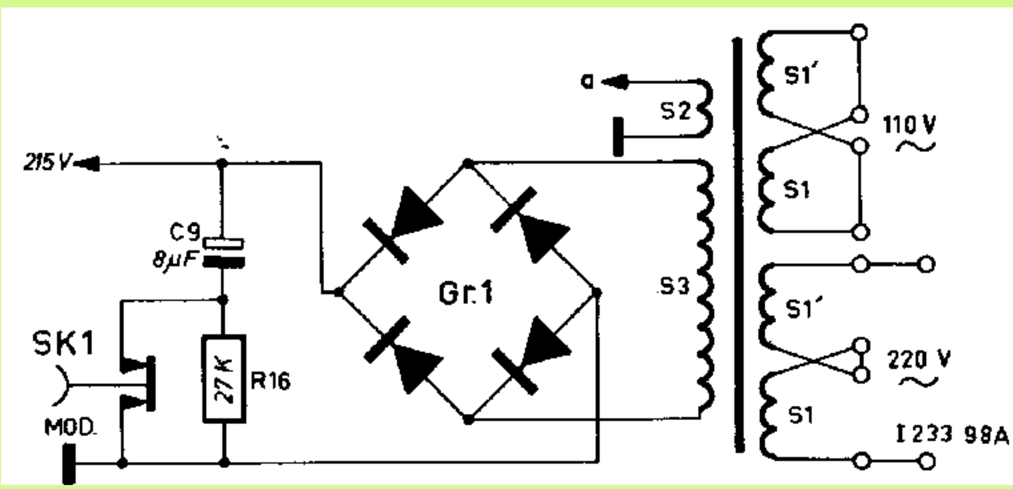
[BACK]()

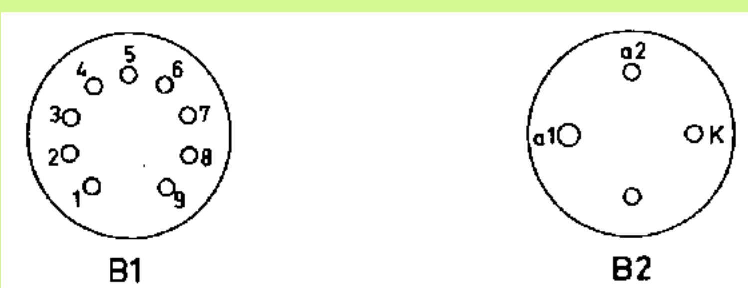
Last update: 2004.10.18

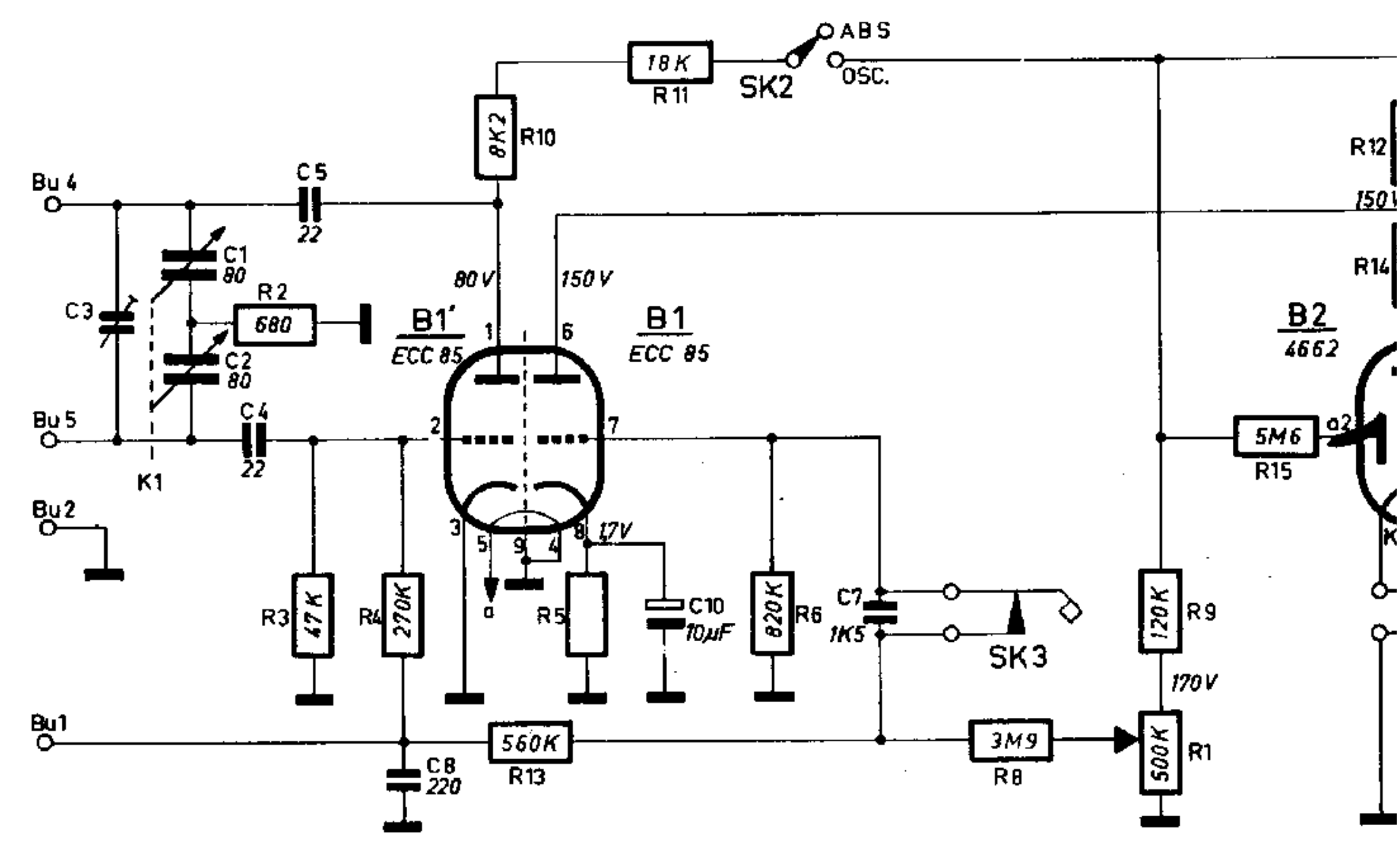
LA8AK

m11. Grid-dip-meters + xtal tester

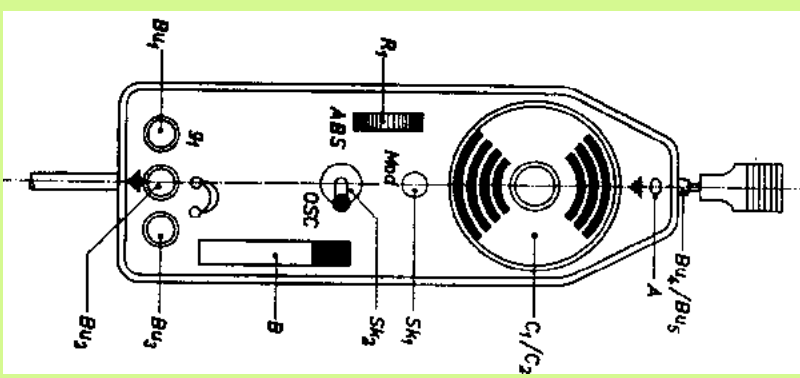
#11.1: Philips professional GM3121 Grid dip meter



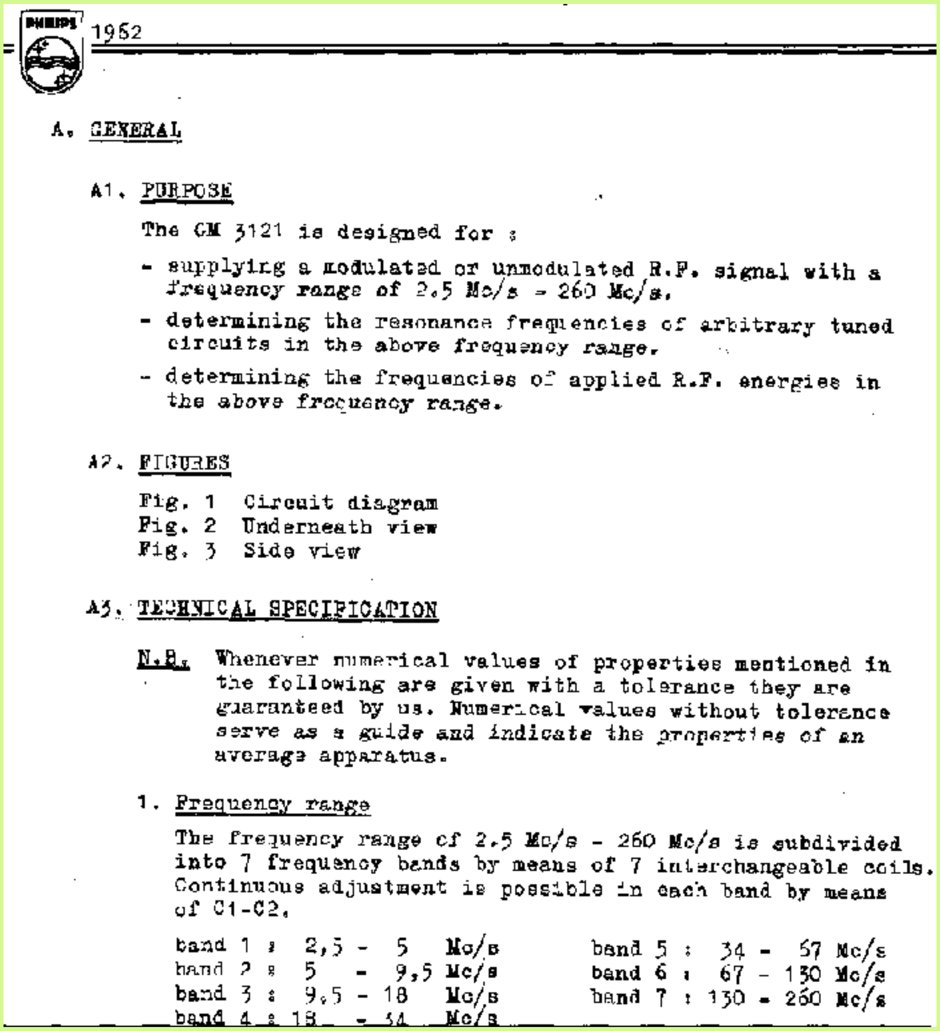




Philips GM 3121 Grid Dip Meter.
Note the Type 4662 indicator valve, this is a very old neon indicator which was used as magic eye in some receivers of the mid 30's, the length of the light depends on the voltage across it, but I suppose it wasn't so useful in the 30's when valves when expensive, wages low, and dual types were even more expensive, but later and in particular when war surplus were overwhelming, prices low and wages higher, it was no reason for not choosing a 12AT7, 6BQ7A or ECC85, so the optimum ideas have really changed, but this circuit is still very rare construction.



GDM data sheet



1952

A. GENERAL

A1. PURPOSE

The GM 3121 is designed for :

- supplying a modulated or unmodulated R.F. signal with a frequency range of 2.5 Mc/s - 260 Mc/s.
- determining the resonance frequencies of arbitrary tuned circuits in the above frequency range.
- determining the frequencies of applied R.F. energies in the above frequency range.

A2. FIGURES

Fig. 1 Circuit diagram
Fig. 2 Underneath view
Fig. 3 Side view

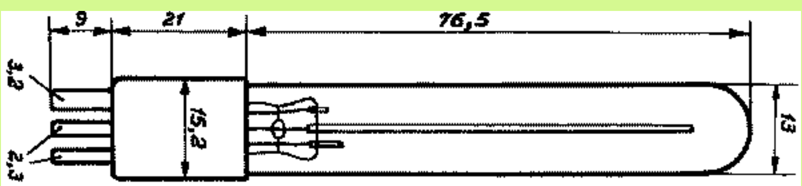
A3. TECHNICAL SPECIFICATION

N.B. Whenever numerical values of properties mentioned in the following are given with a tolerance they are guaranteed by us. Numerical values without tolerance serve as a guide and indicate the properties of an average apparatus.

1. Frequency range

The frequency range of 2.5 Mc/s - 260 Mc/s is subdivided into 7 frequency bands by means of 7 interchangeable coils. Continuous adjustment is possible in each band by means of C1-C2.

band 1 : 2,5 - 5 Mc/s	band 5 : 34 - 67 Mc/s
band 2 : 5 - 9,5 Mc/s	band 6 : 67 - 130 Mc/s
band 3 : 9,5 - 18 Mc/s	band 7 : 130 - 260 Mc/s
band 4 : 18 - 34 Mc/s	

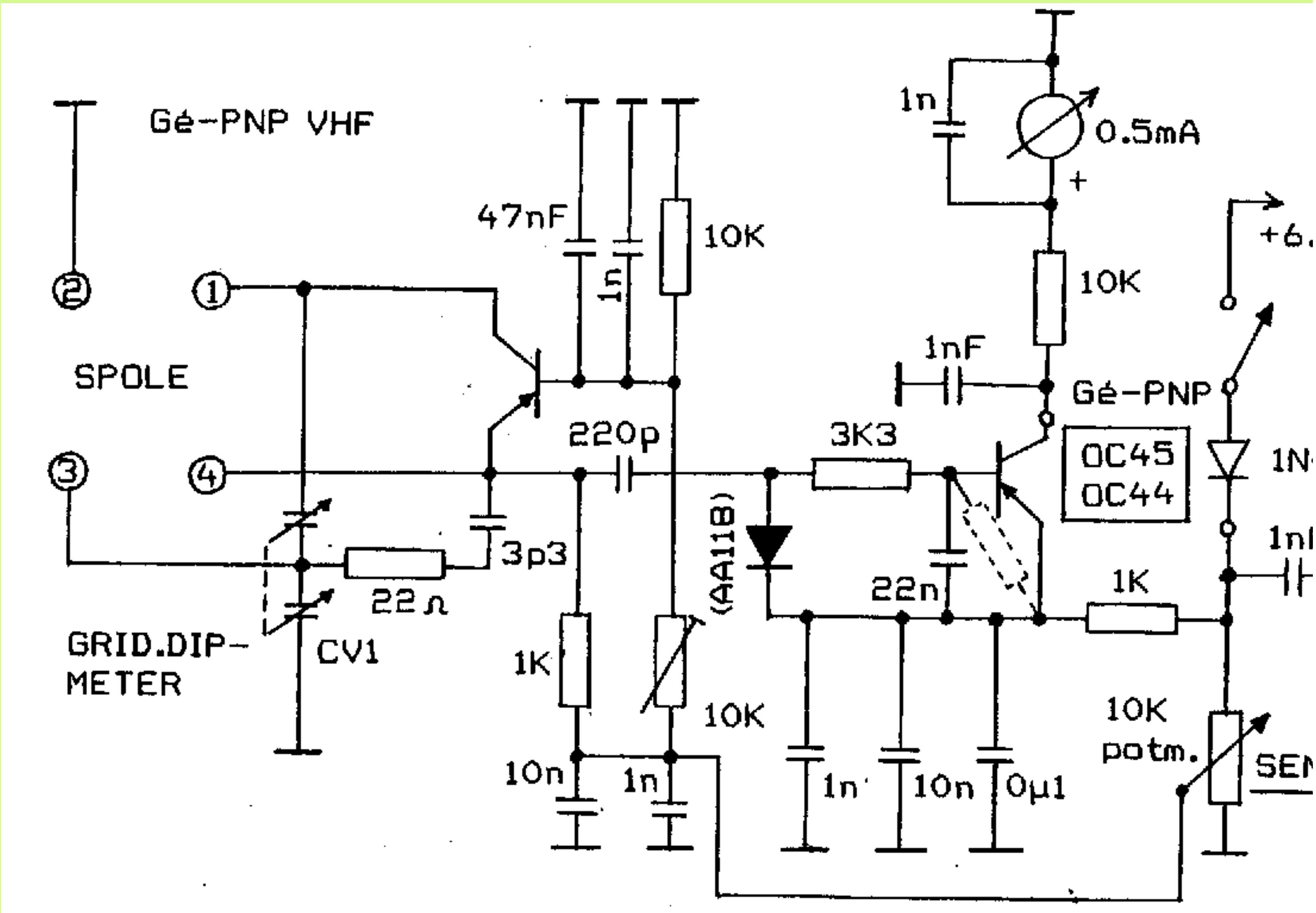


Philips type 4662 neon indicator tube is a strange type of indicator tube, probably designed around 1935 for signal strength indication in broadcast receivers, but seem to have been used very little for this purpose, only one receiver has been found where this indicator was used. But it works ufb for the GDM..
It is easy to find data for it in Frank Philipse's tube database, but the link has changed, so I won't put it here.

#11.2) Tech TE-15 GDM

You may notice that the 2m coil is opened and modified. It also another 2m coil,
but they cover almost the same range. Also note that all **coils and segments** of
scale are **colour-coded**, using the normal colour code: brown-red-orange-yellow-green-blue

Inside view. Have removed some of the rubbish which wouldn't operate properly, and gounded the so-called "negative side" so that it will work on +12V without shortcircuiting against other chassises.

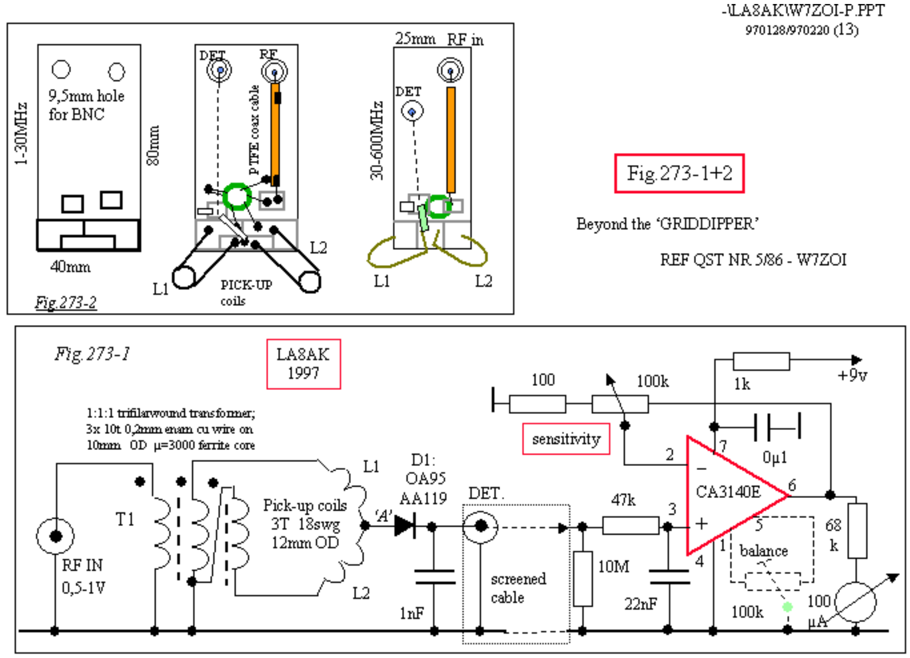


Tech TE-15 Dipmeter (Tradipper).

The instrument was purchased from Schünemann in Berlin in 1967, and have been in use regularly since. One problem was that it uses 9V battery, and it was usually flat when you need it. So I connected it to external 12V supply, but the problem is that it has plus to chassis, and every time the chassis touches other equipment you the wellknown SHORT-CIRCUIT between dipmeter chassis and grounded chassis state occurs. So I decided to convert it to positve supply voltage. The new circuit diagram is shown. As the oscillator frequency isn't particularly stable and clean, I wasn't too interested in the monitor function, it wasn't found particularly useful at all. OC45 (455kHz IF amplifier transistor) is experienced to be one of the best DC-amplifier transistors for low input voltage, better than the audio amplifier type used in the original griddipmeter and was therefore used to improve the meter.

One problem is on the highest range, it simply won't operate properly. The reason was found to be the coil, it is not really a coil, but a short between two pins inside the connector. Remove the short, and wind a coil using 18SWG copper wire, 5turn with 8mm diameter - not critical - it will cover 2m and above it, slightly lower frequency range than it was earlier, but it works as DIPMETER, and you may now dip your 2m coils. I also have the Philips GM-3121 griddipmeter, it is somewhat better than TE15, and must be used with care since the ECC85 exites higher RF level, but I must admit, it is other, better ways to measure coils, but GDM provides an easy way to check resonnances and signals in tuned circuits.

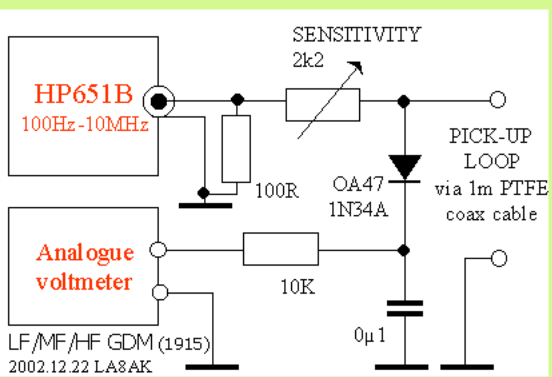
#11.3:



Alternative modern version to the GDM

When you already have a modest signal generator (preferably not thumbweel tuned), but miss a reliable griddipmeter, this may be something to consider. Tom (LB8X) says that MFJ259 will work fine using the described principle, and you need not buy adapter to try (see next figure).
It is not a GDO, GDM or transistor-dipmeter or such, it is an alternative.
The notes below are based on ideas described in an article, see QST May '86 pp.14-20: *W7ZOI Hayward "Simplified Scalar Network Analyzer" p.14* (Feedback Aug p.40), with the subtitle:
Beyond the dipper (using signal generator)
here is shown my version - tested up above 200MHz, frequency limits are somewhat odd to discuss, it really depends on making inductive coupling to a tuned element, and change the shape to fit for different purposes. For UHF strip-lines one side of the probe should be flat for maximum coupling, while on LF - using 88mH toroids it is not difficult to make a 1-2 turns link into the toroid, but it is worse to use with clock cores.

#11.4) **Another alternative GDM**



Dip-meter using signal generator, this is a simpler version of the W7ZOI type dipper, in function is similar to using MFJ259 withthe set of test coils described in the previous notes. It seems important to use a signal generator with large range variation, HP-651B has 10:1 ranges, it is not stable and accurate enough for receiver tests, but very suitable here, toggle-switch tuned generator is hopeles device, you will tune so slow that you won't be able to see the dip

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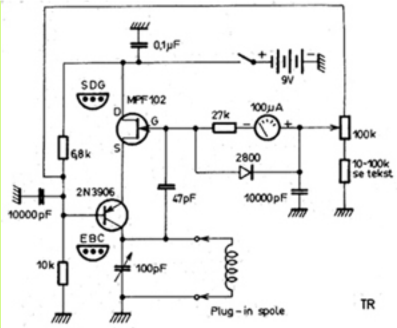
#11.5) Single capacitor type GDM



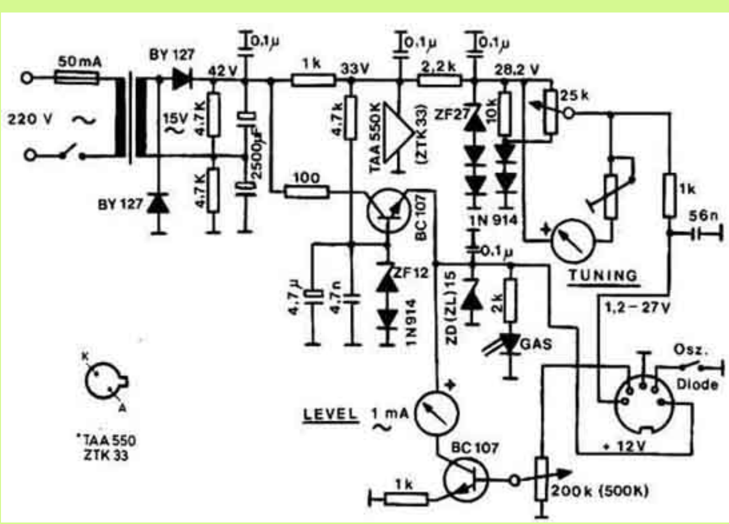
LA7MI dipmeter with single capacitor and coil without tapping (AR pg305 nov 82)

Other means of GDM's to consider (DUBUS VHF UHF Technik Vol.1 1980)
UHF-Dipmeter DL7QY pg.350-355
VHF-UHF Resonance Meter by DJ2HF and DC0DA pg 355-358
Superregenerative UHF Dipmeter................. DL7HG pg. 339-341

#11.6) UHF Dipmeter (DL7QY)

The construction is 25-30 years old and some changes are evident, but still some good ideas could be seen.

This dipper is working well in the range of 130-1400MHz. The high sensitivity enables the user to dip small strip line circuits with good reliability. This is achieved by using for different probes, each containing the whole RF circuitry expecially designed for the corresponding frequency range. The tuning of the oscillator is done with variable capacitance diodes. The tuning voltage is controlled by means of a good potmeter (fig.1), and indicated by a large panel instrument which can be calibrated for frequency directly.



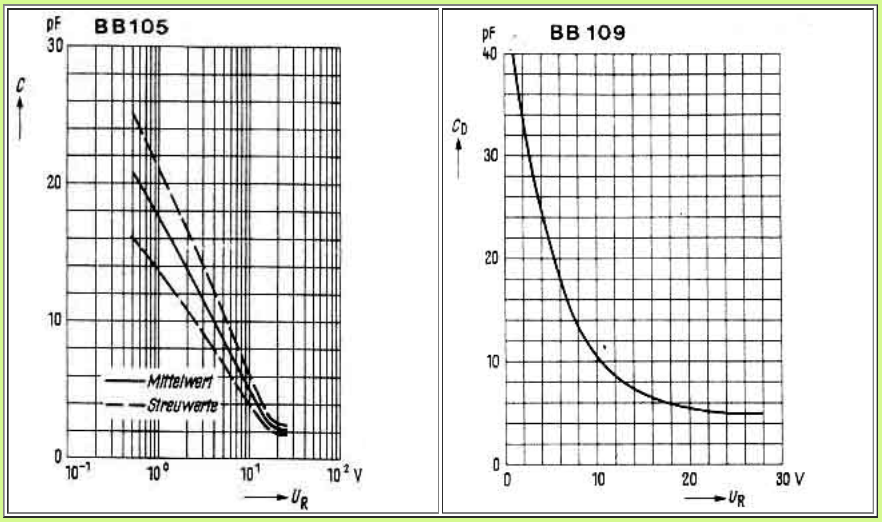
Power supply for DL7QY UHF dipmeter

Two stabilized voltages are needed, +12V for oscillator and level amplifier, and +30v for varicap tuning. Here is used a 15V line transformer with voltage doubler,

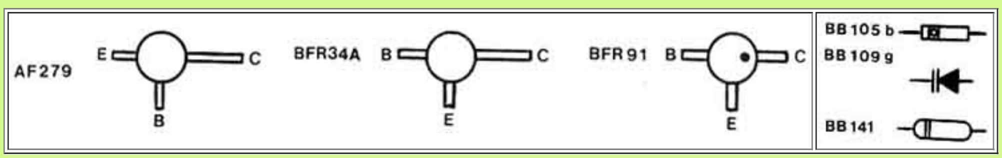
followed by two regulator circuits - as shown in fig.1. The tuning voltage is stabilized twice by parallel regulators; IC TAA550K and a zener diode ZF27, which is temperature compensated by two 1N4148 (1N914) type diodes in series.

Dip-meter RF circuits and level indication:

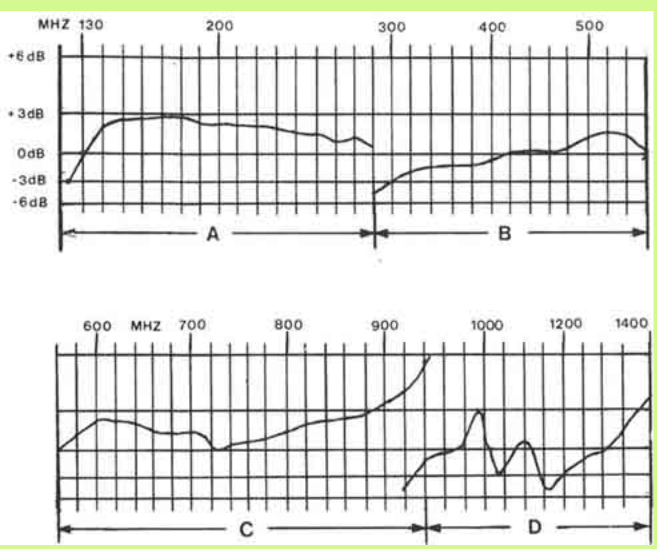
All four probes have oscillator transistors in grounded base configuration, fig 1b shows the connection schemes of the recommended semiconductors. The varicaps are of type BB109, BB105 and BB141. They have low dissipation in the UHF range. Fig 1c shows their capacity variation due to tiuning voltage changing. The oscillator RF voltage is rectified in a voltage doubling circuit in each probe, and amplified and indicated by the remote "Level Indication" meter in the power supply box (fig 1). The rectifier diodes are biased with an adjustable voltage. It is adjusted to that voltage, at which the meter needle begins to rise from zero (when transistor is not oscillating - finger across the U-shaped quarterwave strip-line inductor).
The probes are connected to the power supply unit by a shielded 5-wire cable, using stereo pick-up connectors. The probe boxes are made of tinned iron plate 1mm thick, with outlines of 100 x 20 x 20mm. It is convenient to prepare at first long sheet strips 20mm wide and then cut off the desired lengths. The parts can be soldered together easily.



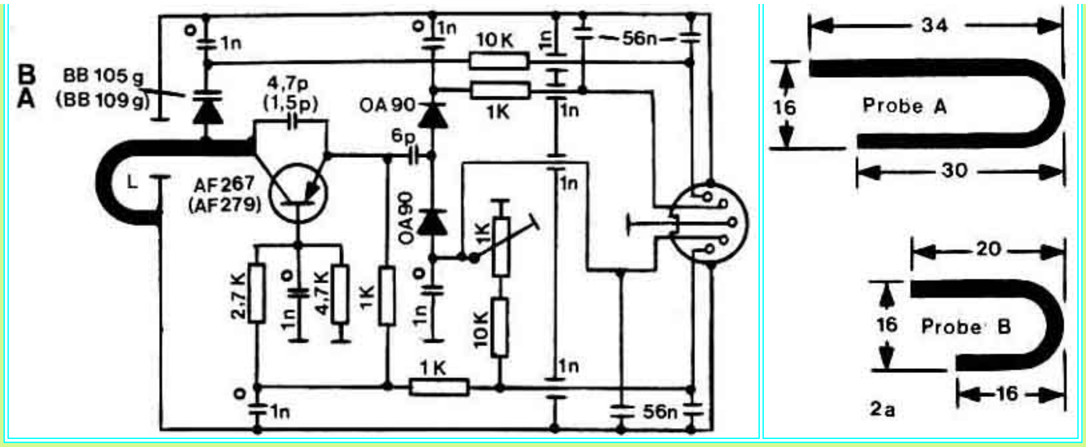
BB105 and BB109 varicap tuning diode capacitance (suppose these diodes are rather old now)



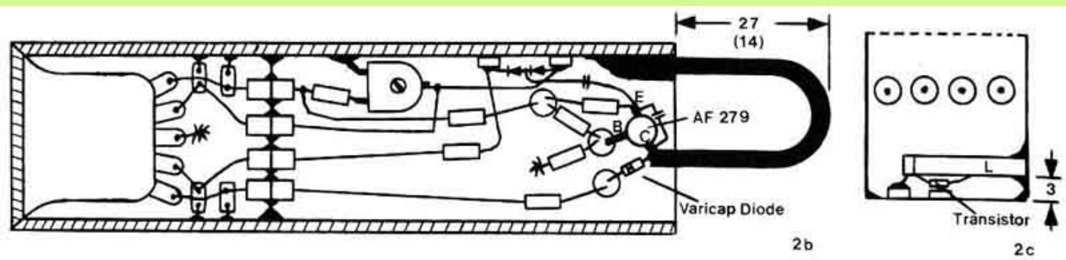
Connexions for the semiconductors
AF279, BFR34, BFR91 (Isn't BF479, BF679 or BF979 some more commonly found PNP devices?)



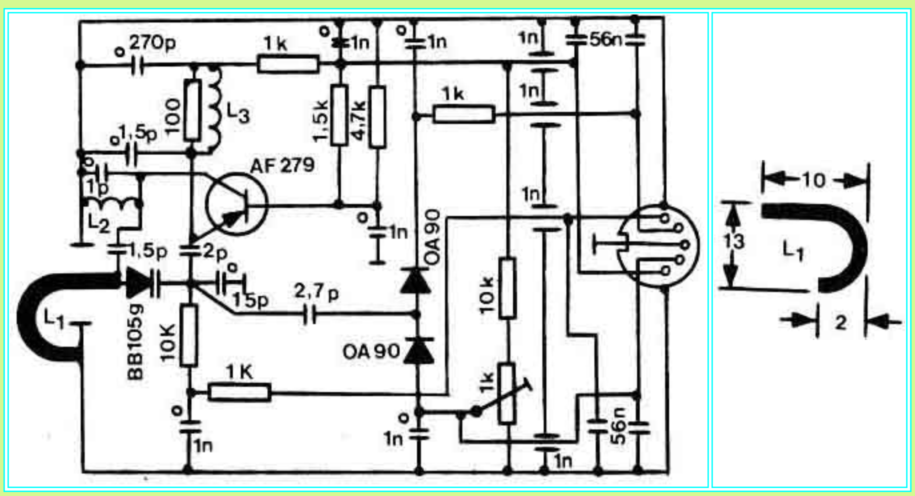
Oscillator levels for the different ranges

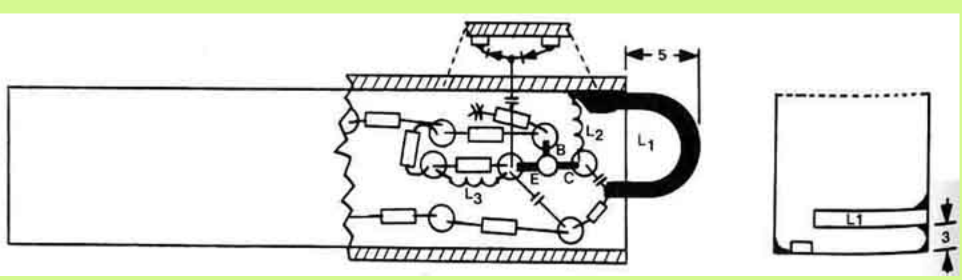


GDM Probe A (130-280MHz)

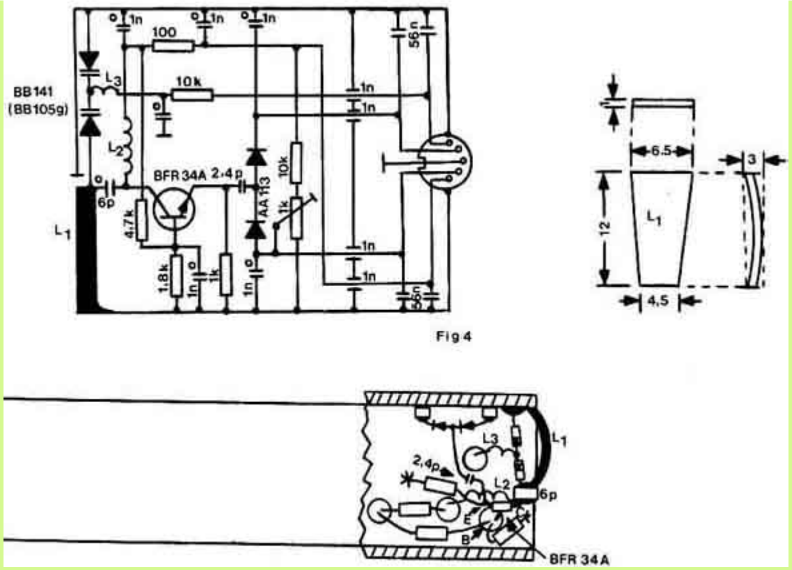


GDM Probe B (270-560MHz)



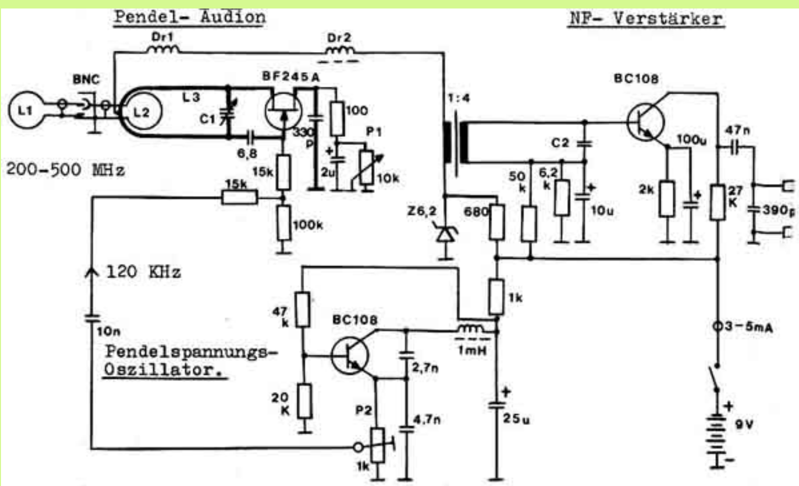


GDM Probe C (530-940MHz)



GDM Probe D. 900-1420MHz (DL7QY).
At this range oscillating was achieved with an npn silicon tranistor of the type BFR34A. Ft=4GHz.
Two varicaps BB141 connected in series tunes the frequency from 1420 down to about 800MHz. Because of the low L/C ratio, good sentitivity is fround from 900MHz and up. The lower part will not be used. Some spurious resonnances with flat peaks occur around 1100MHz. In this range dipping is possible, when the level indication will be recontrolled by turning the potmeter "selectivity". Fig.4a shows the outlines of L1. It is bended to shallow bow out of the probe case to improve the coupling. The front view (fig 4b) shows the arrangement of the two variacaps beneath L1. Their proper sites, especially the nearer the varicaps will be placed to L1, the higher the upper frequency will go.

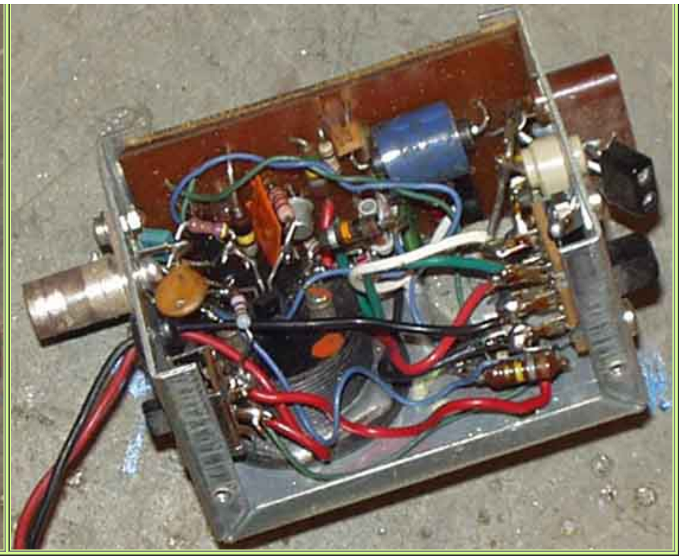
11.7. Superregenerative UHF-Dip-meter (DL7HG)



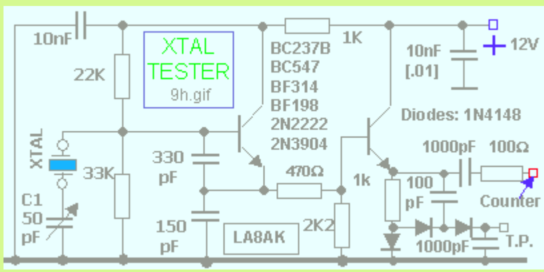
Superregenerative UHF Dipmeter (DL7HG)
DUBUS VHF UHF Technik (Handbook) Vol.1 1980 pg. 339-341

see more VHF/UHF/SHF techniques on page D.

11.9 Xtaltesters



My old xtal tester, built in 1970, and modified several times.



11.10) **Simple xtal tester** which works with a frequency counter. Somewhat more open possibilities for making experiments.
Connect a VOM (preferably an anague type or 100µA-meter with series resistor) to the testpoint may indicate the crystal activity.
It is almost difficult to find a transistor which won't work. It is a good idea to mount some different xtal sockets on a box.
The variable capacitor is measured to 10-30pF.Most NPN general purpose transistors will operate (suppose the only transistor type which doesn't work is 2N3704)

The xtal tester checking if it works with 307kHz xtal - although the optimum component values are for 3-15MHz

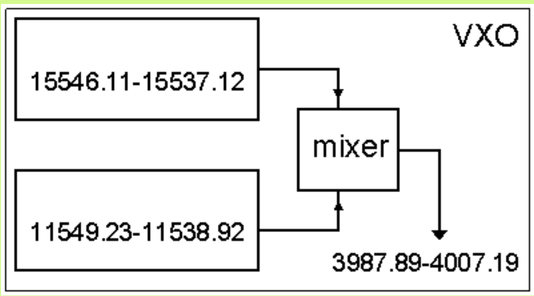
---

11.11) The xtal tester as VXO (variable crystal oscillator)

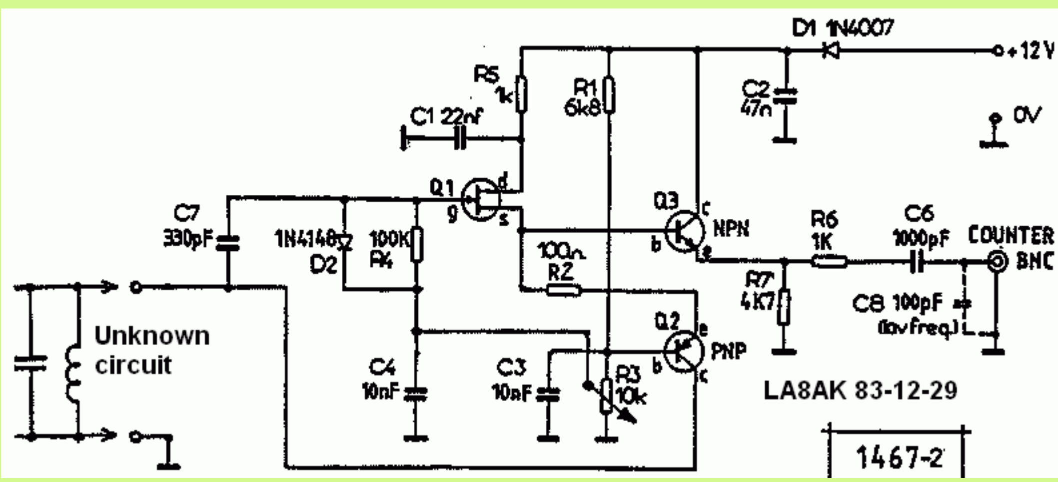
It was interesting to see how much swing I could get with some representative selection of xtals for considering some VXO circuit. The table below is only meant to show the comparison between xtals on different frequencies and overtone xtals operated on fundamental frequency. It is no secret that larger tuning range could have been achieved with some xtals, but that is another story, the comparation was more interesting for my application. In the first instance I am planning a close-in frequency sweep-oscillator to analyse ultimate selectivity of receiver's IF filters.

The 10-30pF tuning capacitor is certainly not optimum, so some larger range might be possible for several xtals, and the capacitors on the transistor could be optimized, too.
If you try to make the tuning range large, the output level may vary a lot, and it may become a problem to limit the output voltage. Too hard limiting may worsen the noise sidebands,

Frequency	F min	max	deviation	notes
3686.4	3686.14	3687.76	1.62 kHz	HC18
9216	9214.80	9221.43	6.63	
11981.35	11983.62	11993.29	9.67kHz	
26786	8927.97	8935.33	7.36	HC18, R/C
27005	9000.60	9007.80	7.2	HC25, C/B
37800	12594.66	12604.51	9.85	HC18, R/C
14318	14318	14328	10kc	Computer
15700	15697.50	15707.80	10.3kc	AP22
46.3	15417.93	15430,6	12.67kc	overtone
13352.080	13350.07	13360.54	10.47	Storno CQM
10700	10746.88	10755.67	8.79	Trio, HC6U
11541.34	11538.92	11549.23	10.31	HC6U, 30pF
14 866.0	14 864.54	14 874.37	9.83	AP22
15 539.30	15 537.12	15 546.11	8.99	AP22

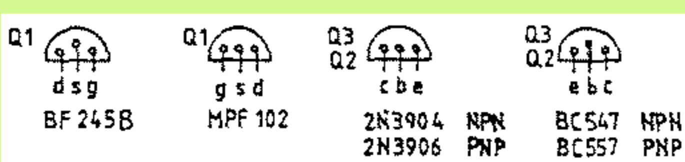


Improved variable xtal oscillator (VXO)

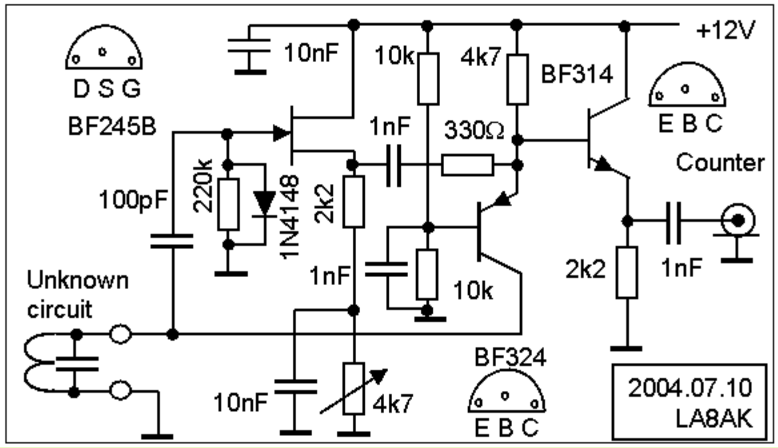


Resonance tester.

A sometimes useful instrument, when it is not possible to dip a tuned circuit, it may be placed in a screened can. Problem is that it doesn't always work, perhaps it is room for improvement here. It is neccessary to have DC-return via the coil to instrument ground. In some cases an RFC could do this, but often it would upset the measurement.



connections for some actual transistors



It seems problem with definite dc level on the second transistor, and excitation control for the first stage, so it seems after few tests that this could be a solution. It doesn't pull the frequency down much compared to the dip-meter frequency. A later version using BF245B, BF324 (PNP) and BF314 (NPN), the two latter semiconductors has same pin connection as for BC547/BC557, in spite of what data sheets may tell! Wished to use some definite RF devices, but if they are difficult to find, replacement for BF324 is 2N3906 (=BC557 and BC558), and for BF314 is 2N3904 (= BC547, BC238), MPS918 or BF199 types are better NPN devices.


The last version (minus one). The coil shown has very high Q, it is the tank coil from Heathkit HX-20

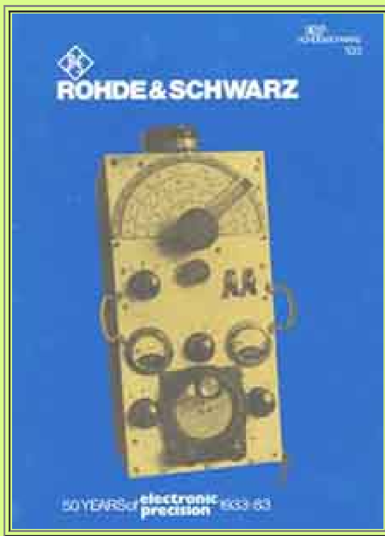
Email: [redacted] c/m

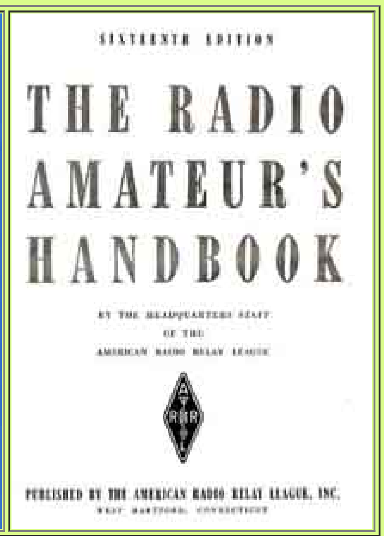
[BACK]

Last update: 2005.01.08

LA8AK

m1. LC- and Q-meters.





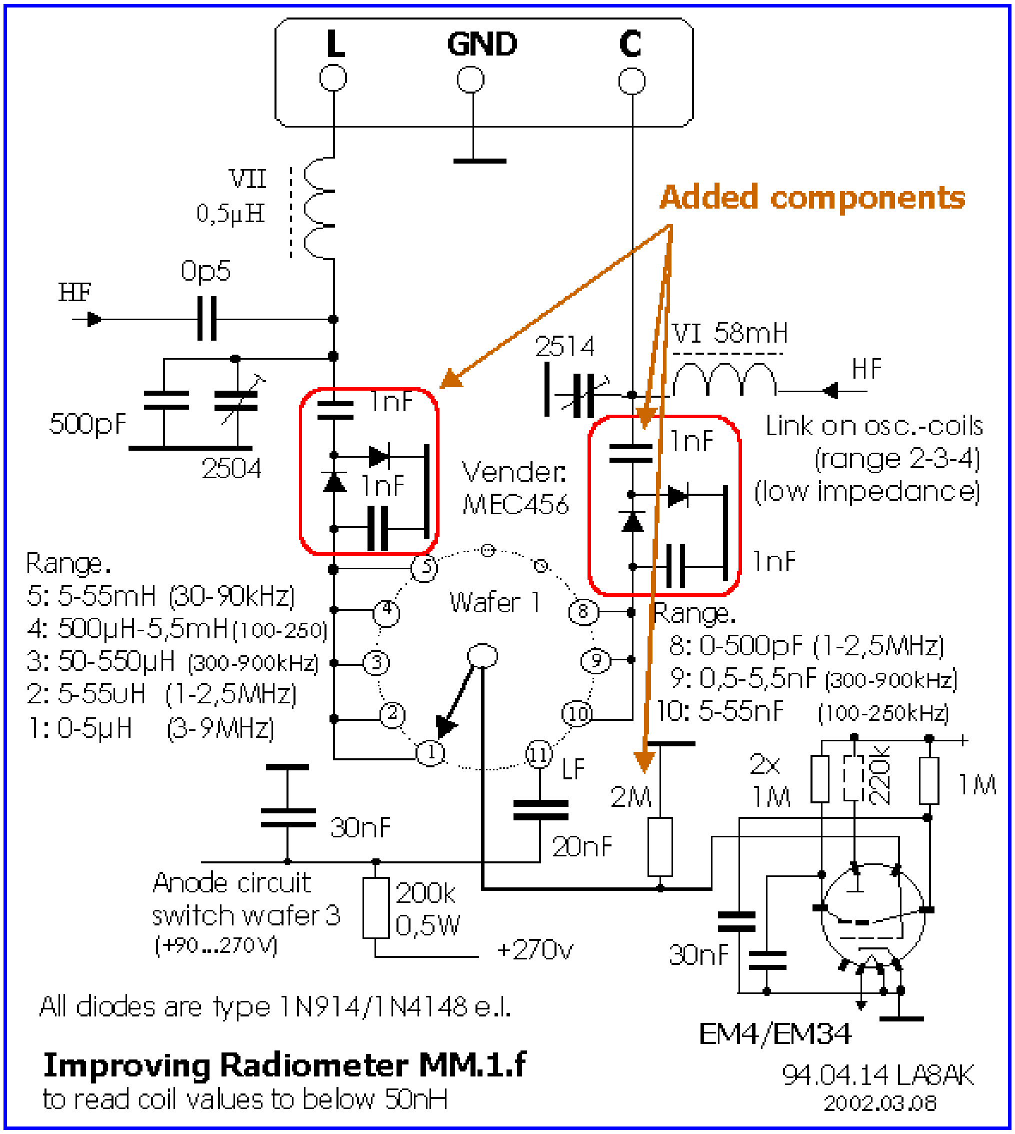
Several old constructions and instruments are still a good idea to use today, the Rohde & Schwartz 50 years anniversary book contains several stories about some of their oldest, but highly appreciated instruments.

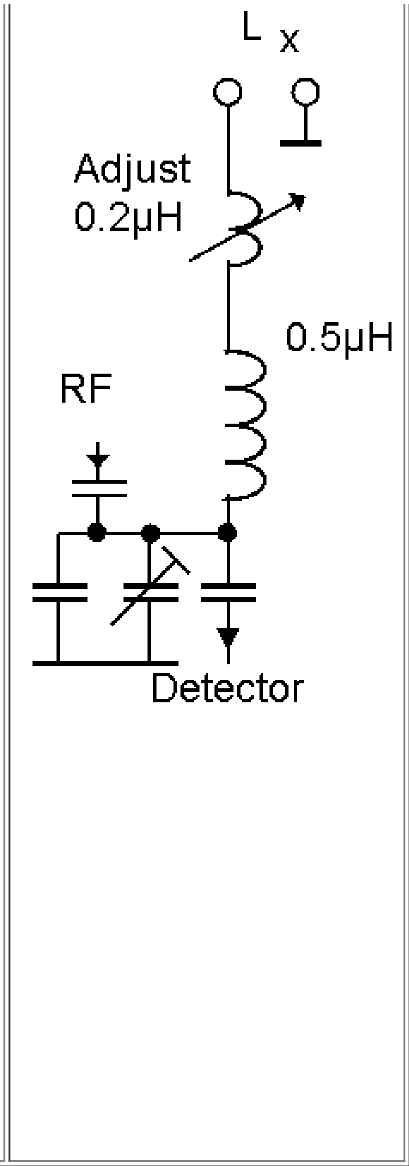
1.1)

Some German LF/HF-coax connectors from the 50...60's.
Above is the coax connector usually found on CF instruments from Wandel&Goltermann and Siemens, and below is the Fernsehen connector which is practical for video switch panels. I use them for selecting between HF antennas. (also shown on page m-12)

1.2) Analogue RCL-measuring instruments

Radiometer MM1f, an old, but still very useful multimeter to maintain!





Radiometer MM1f multimeter.
Modification in particular to achieve better reading between 20nH-2μH coil inductance. Note the series coil, it is the secret why it is possible to measure inductance values down towards zero. (Since it is a gif file it prints better than it seems on the screen). It is usually no problem to find inductance values with this instrument when the instruments fails to work. Also have a digital L-C-R-meter and some Q-meters, but the old 1950-vintage instrument seems still worth to maintain
.
A suggested compensation for home-brewing instrument, to null out the extra connection wires with alligator clips, in my case they measure to 150nH

1.3) Radiometer QM1f (50kHz-70MHz in 8 ranges)

It seems sometimes difficult to use if you don't already know the inductance or resonnance frequency. Won't modify as it probably upsets calibration, the only modification is a mains socket on the rear and a BNC skt for frequency counter. The screws for device under test is bad design and it is often difficult to fix the coil wires properly, they tend to fall out when screws are tightened. Perhaps it was invented before they started to make holes in the screws?!.
The Q-meter detector uses an EF6, see note further below

1.4) Build your own Q-meter calibration coils

Received note (not edited): I can give you some detail if you like using an Amidon core as an example. I would think the "Q" will vary some with "doping" material used to hold the turns in place, wire spacing around the core, and consistency of the core material itself (maybe other factors). I bring up the last point because these Amidon "yellow" cores appear to be operational at a lower range than their charts indicate even thought they mention that larger cores tend to peak towards to low end of the range.

Amidon T-50-6 core, Permeability 8, Freq range 10-50Mhz, color - yellow

Winding - 23 turns of #22 wire
Spacing - equally spaced around toroid
Doping - none
Inductance - 2.5uH

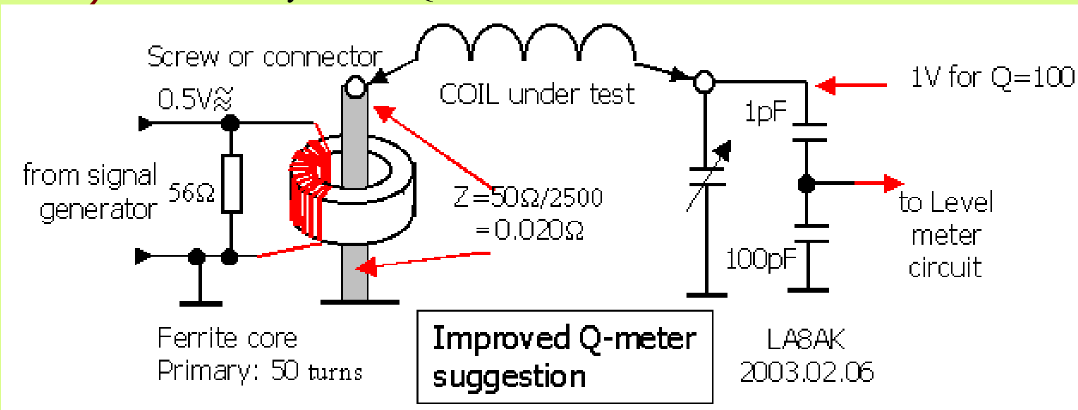
Results:

Frequency (MHz)	Capacitance (pf)	"Q"
7.9 8.5	150 134	340 350
9.0 10.0	119.4 94	355 355
15.0 18.0	41.5 28.5	340 296
19.2	25	284

73s Kees K5BCQ

Boonton 260A Q-meter:
http://www.qsl.net/k5bcq/qmeter/qmeter.html

#1.5) how to build your own Q-meter



An idea how to build your own Q-meter, with the shown ferrite core transformer you easily make very low feed impedance I redesigned my Heath Kit QM-1 meter using this technique, and used a 6BA6/EF93 as grid detector, based on the principle used for Radiometer QM1f, this uses a Philips EF6, and I believe it is better than EF93 which I ended up with as only **modern** alternative, while EF94/6AU6 didn't work at all.QM1f uses a small resistor and requires quite heavy excitation to achieve high enough drive, and a thermocouple to measure the power. But this is much easier with the described ferrite toroid technique, since you may measure the level on 50Ω side.

Had some discussions with Dick Rollema PA0SE regarding detectors, and he proved that 1N4148 type detector, didn't load the circuit so much that it couldn't be used in a Q-meter, but of course it depends on the frequency and minority carrier life time

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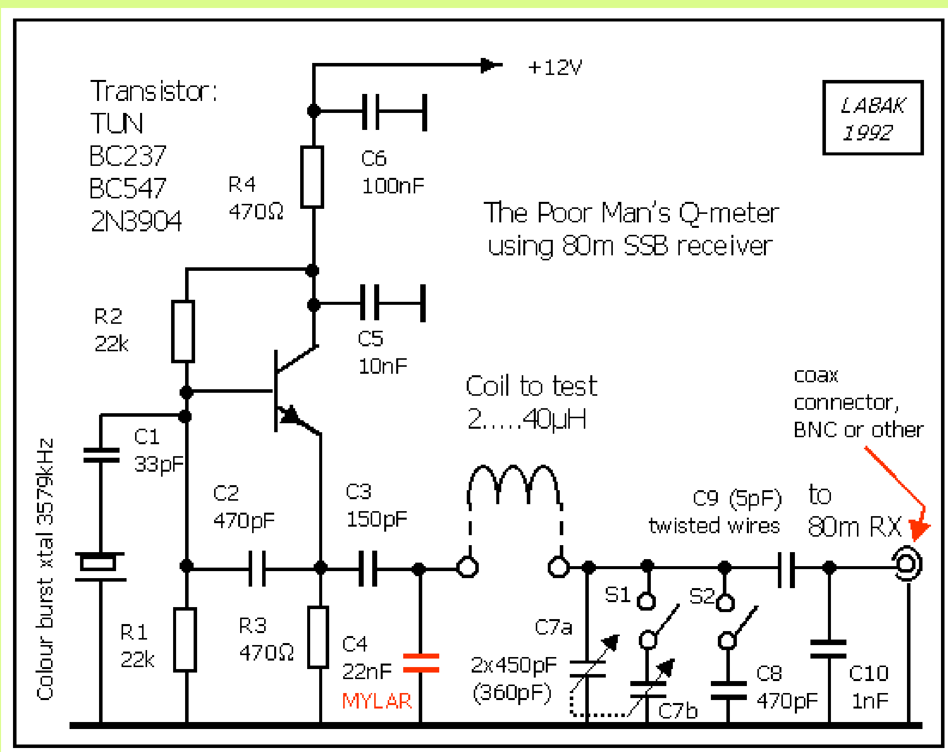
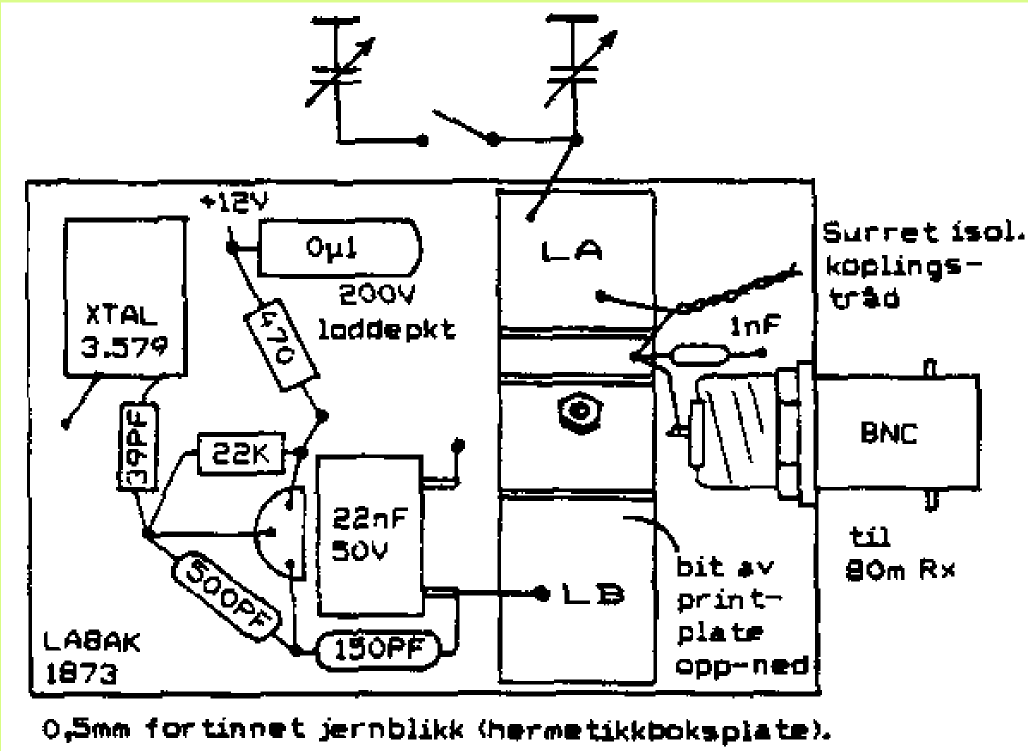
#1.6)



The poor man's Q-meter

It was constructed as a comment to a SPRAT article to demonstrate how cheap it was possible to make a coil measure meter, suppose it could be built for less than £2.50, but depends on what you have in your junkbox. American broadcast type capacitors seems to be 2x365µµF, while the European standard is 2x450pF or 405+455pF (since we have the longwave AM broadcast band, too), it is really not so important. With different capacitors you may tune to resonnance and coils be calculated when you know the capacitance. You use an 80m receiver and the S-meter deflection indicates the Q-value. It is important to use a good capacitor at C4, not such disc ceramic(!) type, the other capacitors are not critical in other ways than that they may influence the frequency stability. C9 should be small as possible, since the signal into the receiver is certainly strong enough, it consists of two insulated

wire ends twisted together.



Suggested construction on a piece of copper laminate using the dead-bug method

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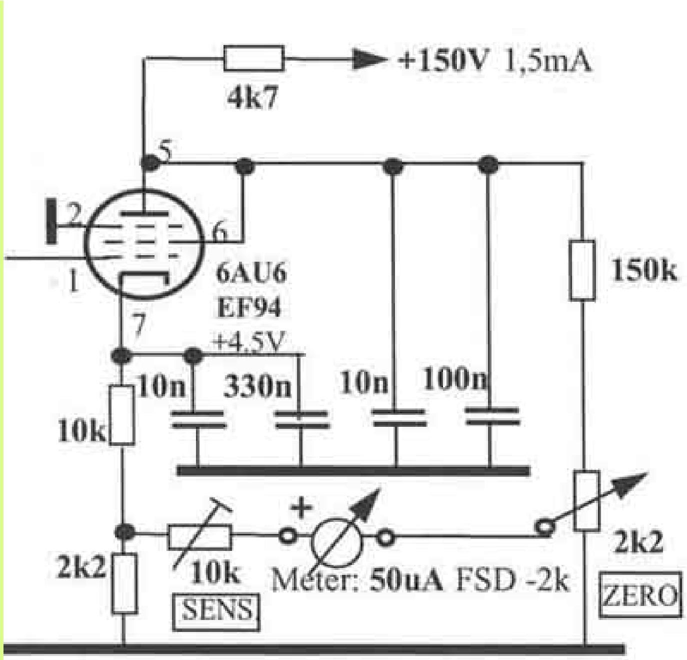
#1.7)

Heathkit QM-1. (140kHz-18MHz in 4 ranges).We bought some in 76 when they were offered at half price.
It has reasonable accurate Q-readings, but I never managed to align the frequency properly over the band. 6AL5 detector was a problem, mine drifted, but somebody else believe the diodes could be selected. Must admit that I used QM1 for several experiments, and it is now far from the original, but possibly totally out of calibration. Ended up with a 6BA6 detector in a similar circuit to the one in Radiometer QM1f using EF6.

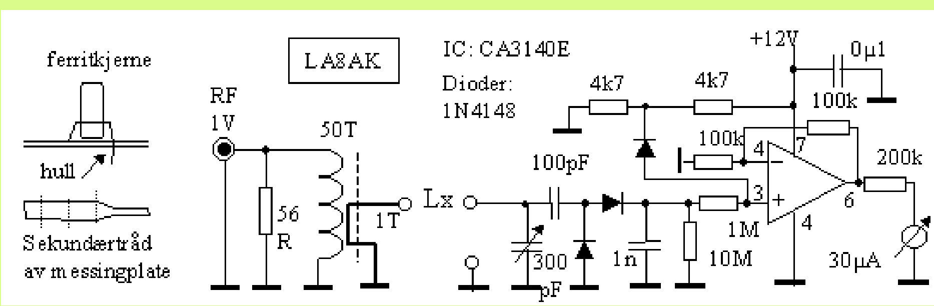
#1.8



Q-meter. Grid detector using 6AU6 used with Heath QM-1. The grid circuit must have dc return circuit via the coil. The original is used in Radiometer QM1, but has an obsolete type, EF6 which seems somewhat different from more modern type pentodes.

Had some discussions with Dick Rollema PA0SE regarding detectors, and he proved that 1N4148 type detector, didn't load the circuit so much that it couldn't be used in a Q-meter, but of course it depends on the frequency and minority carrier life time, so the usage may depend on operational frequency.

#1.9) Q-meter construction



Q-meter. An alternative circuit: The primary consists of a brass plates which passes through the toroid core.
It would be some improvement in coil loading if a voltage divider goes to the diodes or an
RF amplifier could be used as buffer.

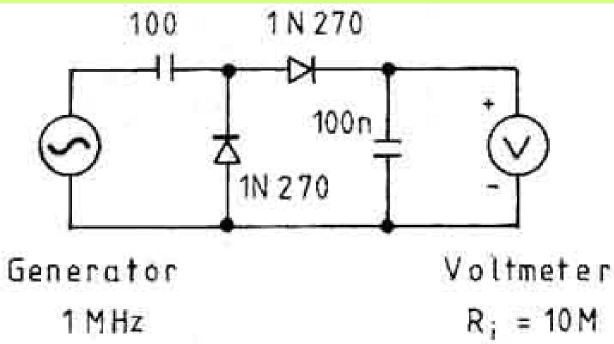
Notes for building your own Q-meter.

The first problem to consider is that you need a defined RF voltage to use this technique for building your own Q-meter, the second is perhaps even worse; the detector should not load the tuned circuit. With 20mV excitation to the coil and Q=50, the voltage on the hot side is 1V. So if you attach a 1/100 voltage divider for connecting a 50 ohm amplifier, you will transform a loss resistance of 10000 x 50 = 500kΩ to the hot circuit and this is really too much for a good Q-meter. I would reckon that an integrated circuit detector need at least 100:1 detecting range, so it is not a good solution. Dick Rollema PA0SE mentions the diode detector, and perhaps, but it must be checked what the dynamic impedance is, and worse is the diode characteristic which should be checked properly for any detector intended to be used.
On the other hand, you may always build something which works, but you don't know the actual calibration, and you may have good use of it whether it is perfect or not.

RF detector with 2x 1N270.
LA7MI Stein Torp made some measurements of a voltage doubler with 2x 1N270 on HF:

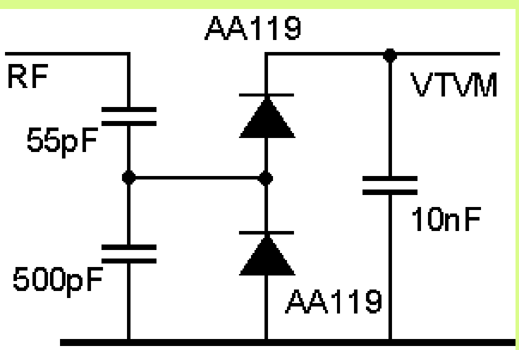
RF (RMS) 1MHz	Detected DC	RF (RMS)	Detected (DC)
10V 5v 2v	28V 14v 5.4V	100mV 50mV 20mV	187mV 50mV 13.7mV
1v 0.5v 0.2v	2.6 1.25 0.45	10mV 5mV 2mV	3.4mV 0.85mV 0.137mV

DC output from a voltage doubler with varying RF voltages (LA7MI, Amatör Radio 1985-11 pg 299), note that detected voltage may decrease for higher frequencies, but not so much below 100MHz.



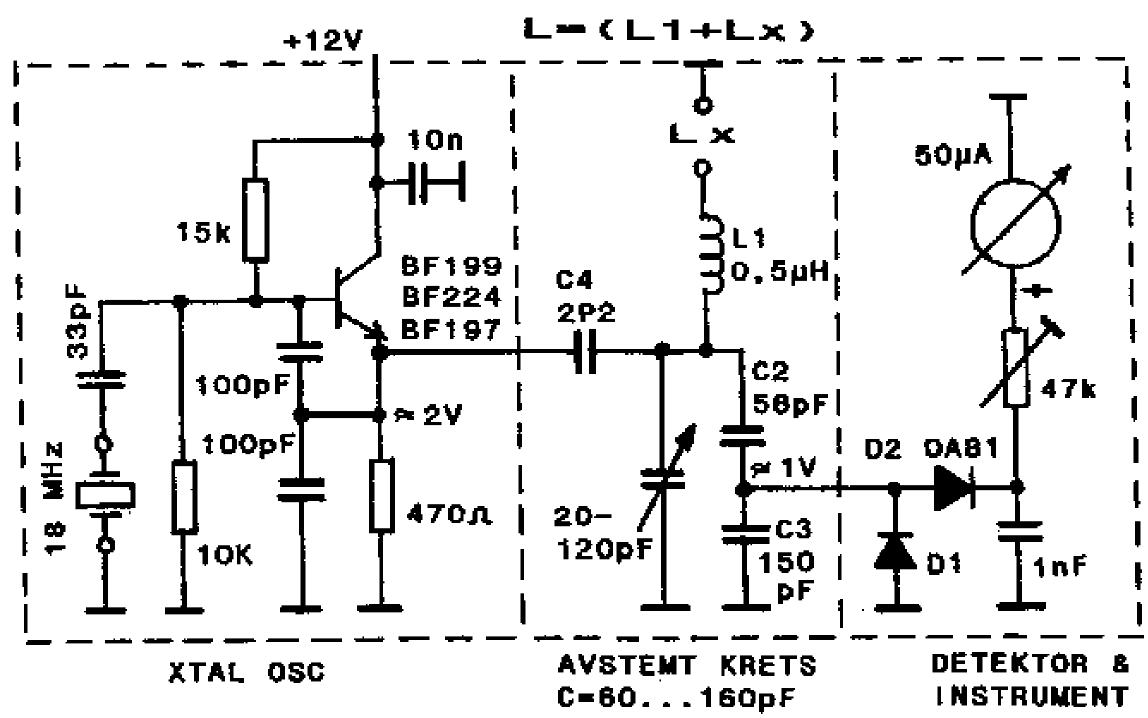
He constructed a quasi-compensating amplifier with CA3140E so that the reading was within 20% accuracy. It is described on one of my pages, but I am not capable of finding it now. It may also be mentioned on page **m2** as "LA7MI LF/HF/VHF/UHF mV-meter". Some other possible diode types are OA95, AA118, AA119, AAZ15.

If output voltage is not critical, you just want to see some DC change as RF voltage varies, see sensitive RF detector using silicon diodes (1N4148) on page **m2**



The problem with the detector is that it must have very high impedance, the characteristique must be predictable, and the performance must be checked and calibrated. A problem with germanium diodes is internal capacitance, so they should be applied with an RF-voltage-divider, a suggestion is shown here.

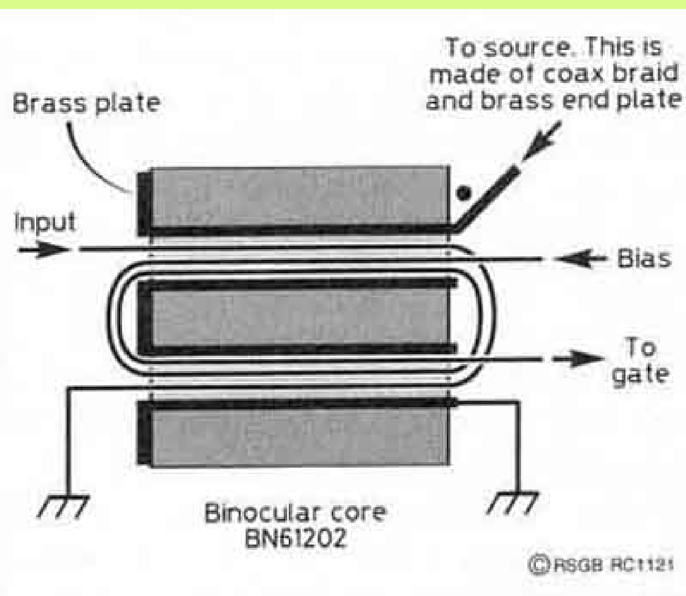
#1.10) Measuring small coil values



It is often difficult to measure small coil values, this construction works fine down below 20 nanoHenry. The secret in measuring such small values is to add a 0.5-1µH coil in series with the coil under test. This extra coil should have high as practical Q-value (dependent on you desires). Q-measurements may not be accurate, but you can measure coil vales down to zero.

See also the notes and modification for Radiometer MM1f which uses the principle mentioned with the extra series coil.

#1.11) Another RF transformer construction for Q-meter



Another suggestion is to use an RF-transformer described by **W4ZCB** for another purpose (ref. 3): To minimise leakage inductance, the single turn braid must use brass end plates so the braid can be opened up and pushed into contact with the sides of the hole in the binocular core.
However, reasonable results can be obtained with just the braided with enamel inside and no end plates.

References:
1) Zwischen-Basis amplifier with J308 2) G3SBI Radcom TT Dec 95 pp70-71
2) Zwischen-Basis cascode-amp. with J310 1) G3SBI Radcom TT May 95 pp60

3) Zwischenbasis amplifier W4ZCB and G3SBI Radcom TT Sept 96 pp70-71
4) Zwischen-Basis JFET amplifier 4) G3SBI Radcom TT Sep 98 pp 58-59

See the original notes on page **Page r22**
(2003.08.06)

#1.12) Edge-mounted p.c.b. tool

Some useful tool to pull out PCB's with edge-contacts. The shape varies for different manufacturers of telecommunication equipment

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page-994 List of contents

Email: [redacted]

Back

2004.07.01

LA8AK

M2 RF detectors, level meters, attenuators, RF termination (dummy loads),signal dividers

#2.1) Surplus attenuators

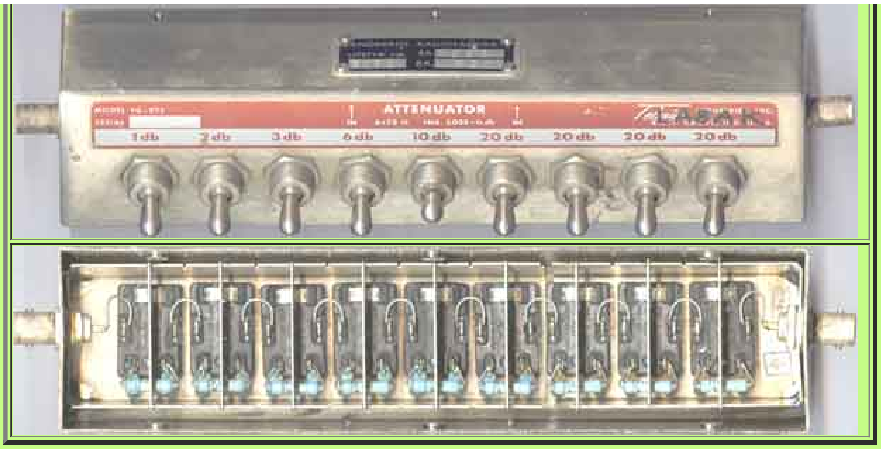
Muirhead & Co No. 355748, it has 0-61.5dB in 0.5dB steps (75 ohm).

Problem with attenuators is that when you need them, you can't find sufficient amount of them. I've often needed 3 for some experiments, and 75ohm attenuators in a 50 ohm system does not cause much inaccuracies, so when you have checked it and are aware of the possible problems you just don't care so much.

Another argument is that I use a lot of available cables and equipment from work which are made for 75ohm systems, and it saves me a lot of trouble to use what is around instead of buying what you really don't need.

Inside look of the Muirhead 75Ω attenuator (boatanchor). It is well screened between the sections, but isn't much looking like an instrument for VHF, on the other hand it seems to be good - at least for the lower part of VHF range. It came with some Marelli radio link equipment and I had to change the connectors to BNC. Have passed some to other amateur radio experimenter and they are quite satisfied with using them for 50Ω. But again you need to be an electronics engineer - with 30 years experience to understand how easy it is!

#2.2) Telonic Model TG-975 (First owner: Tandbergs Radiofabrikk, year: 1965)



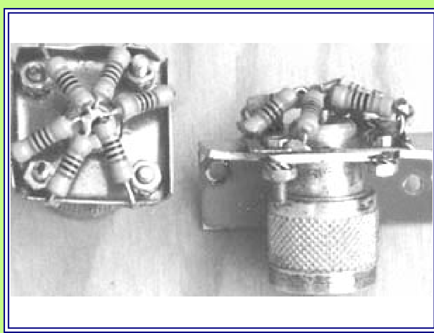
Another 75Ω (0-102dB) attenuator I bought in 1980 because it looks so easy to repair. Has used it on VHF and 70cm (50Ω), when you are aware of it it is only marginal difference between a 50ohm and 75ohm instrument. The switches are mounted between the different rooms with the resistor through holes.

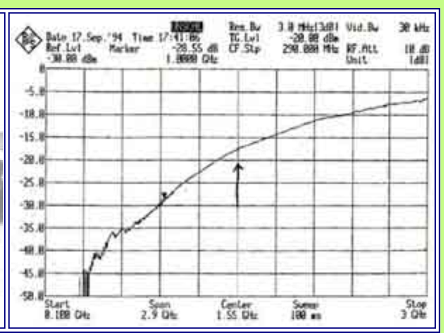
#2.3) **Danbridge Decade Attenuator type DA3HS/D**; 600Ω, 0-111dB in 0.1dB steps.

Decade resistors and decade attenuators are among those items I regard as waste or time and money, but I got it from work, and have never used it, or missed it. Such things are usually believed to have a value by persons who don't understand much. I wouldn't use a decade restance unit to find a resistor value! This unit is better for next junk-sale.

(S.: atenaters)

#2.4) Practical VHF/UHF Dummyload to build



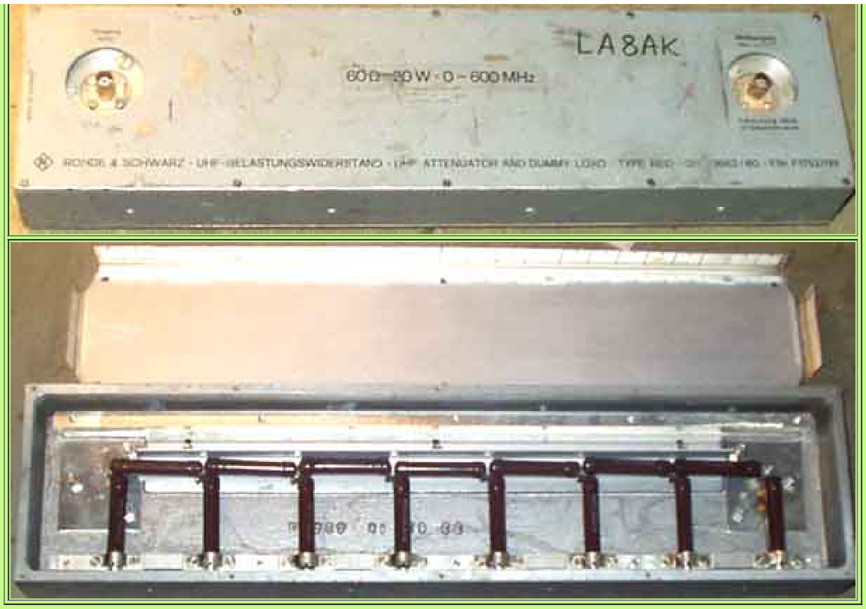


Building termination with standard components is easier than people think!
But, usually experience is better than thinking.

Practical dummy-loads mounted on N-connectors. Using male connector it can be connected directly on the Bird Model 43 wattmeter. it uses 6x 300W 1W Draloric LCA0414 carbon resistors. To ease soldering a timmed iron plate is attached to the connector first.

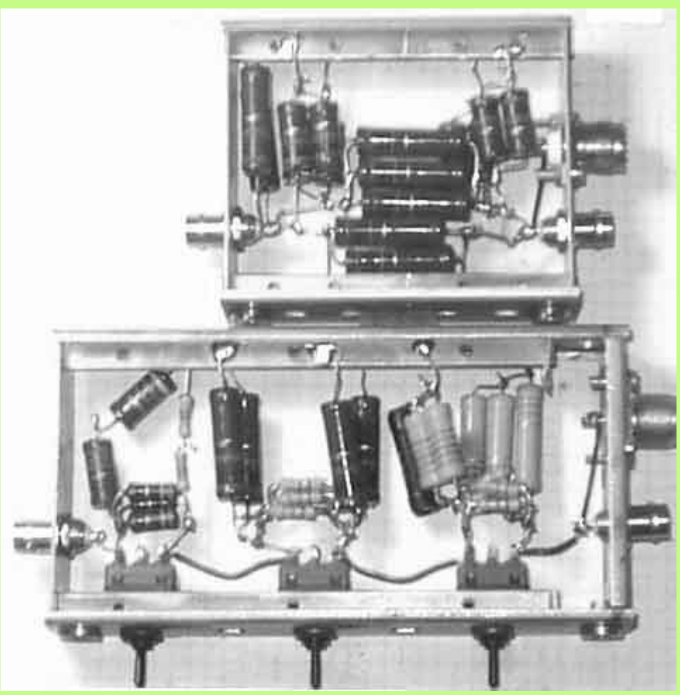
The Rohde&Schwartz team offered to measure it at a their stand at the Weinheim UKW Tagung, the one with male connector has almost **20dB return loss at 1300MH**z, - not bad for standard type carbon resistors! Only had one available.

#2.5) Power Attenuator (25W 30dB)



Rohde&Schwarts RBD 600MHz 30dB attenuator uses discrete power resistors, note the frequency limit, it is professional equipment! The attenuator is original 60 ohm, so I have modified it with some extra resistors to 50 ohm. The original Dezi-fix connectors were easily changed to BNC.

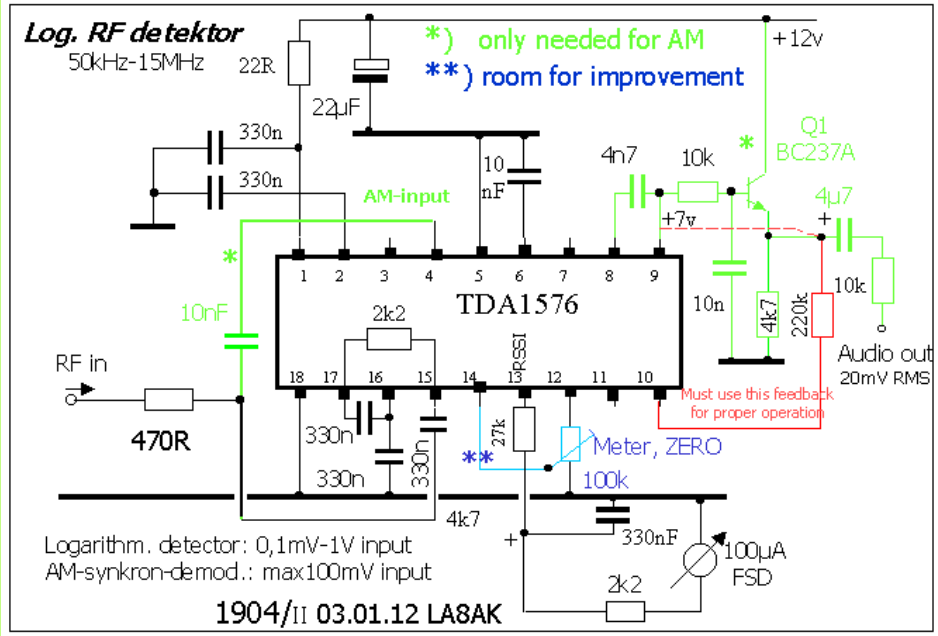
#2.6) more power attenuators



Some power attenuators used for experiments on HF

High-level PIN-diode attenuators, see page c11

#2.7 RF Level meter using Philips TDA1576



10a) TDA1576 (Philips) as level meter, has 70dB range. But using the internal meter offset adjustment circuit upset the range, so it seems better to use an outside circuit. Also useful as quasi-synchronous quadrature AM-demodulator, but it is overloaded with larger than 100mV input.

Bird's nest using TDA1576 as a general purpose detector for 10kHz-15MHz

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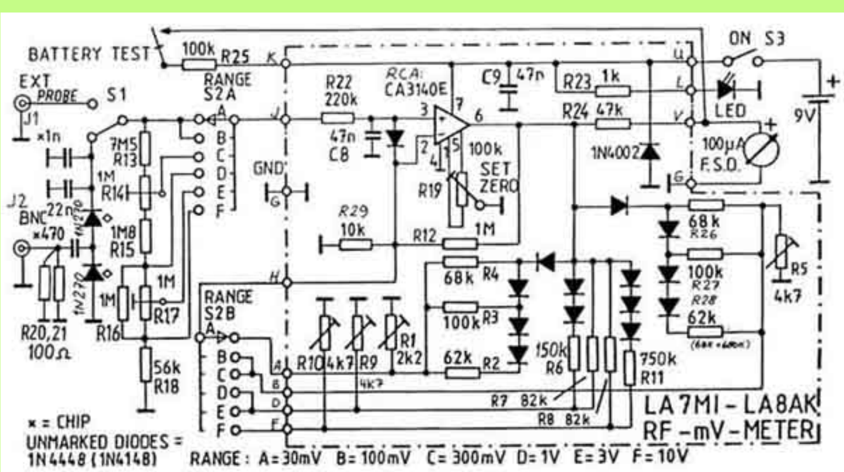
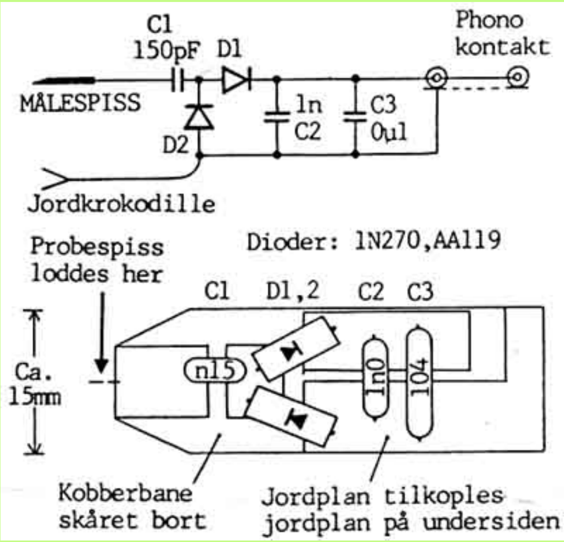


#2.8 LA7MI linear scale RF-mV meter for 0.01-1500MHz.

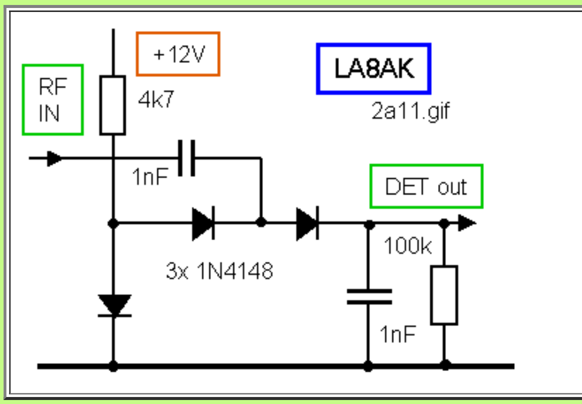
Believe it measured better than 10% accuracy to a linear scale on all ranges except the lowest (30mV) up to 500MHz. It was not intended to by LA7MI to have this range since strong transmitters in the neighbourhood gave over 30mV deflection with the high impedance probe, but I added it in my version since I mainly measure 50 ohm circuits via coax cable, and only very seldom use a high impedance probe. Also used it with small coax loop to align local osc for 2320MHz

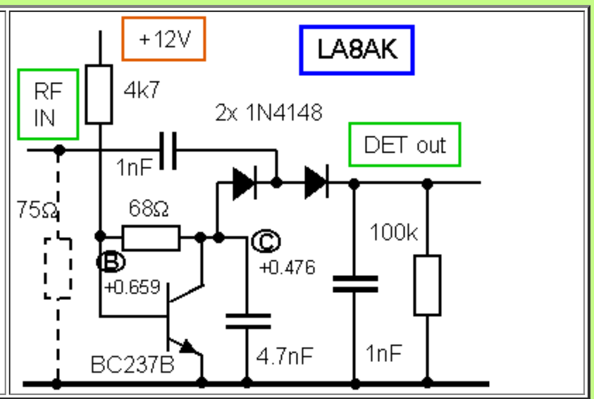
transverter.



RF probe for RF mV-meter. Ground on two-sided PCB laminate component side is connected to the screen side below.
The board patterns is fabricated using hacksaw. The construction is so self evident that I believe you don't need to have the words translated, it was only a point in the first amateur radio magazine it was presented, and as such not shown in DUBUS.
jordplan=groundplane, probespiss loddes her =probe tip soldered here, jordkrokodille = crocodile clip to ground.

See also the other alternative instrument described below.





#2.9) RF detectors using 1N4148 type silicon diodes.

An extra diode is used to forward bias the detector. It has relatively low impedance and decoupling is not usually necessary. Using a transistor instead of the diode it is easier to optimize the forward bias voltage, but the voltage drop over the diode is current dependent, and still with 250mV forward drop it draws some current. Another problem is temperature stability.

Supply voltage	Base voltage	Collector voltage	DC output voltage
9v	643	518mV	44
12v	659	476	34
15v	649mV	438mV	26

It is important that the supply voltage is stable to use the circuit shown above

RF input (450kHz) RMS	Detector output (2nd circuit)
--	+30mV
25mV	+33mV
80mV	+58mV
250mV	+300mV
400mV	+625mV
800mV	1.568V

The detector is not linear, but may be useful for several non-accurate purposes

---

c42 Variable bandwidth xtal filter with constant gain using negative impedance amplifier - (a technique used in HP141 and similar instruments)

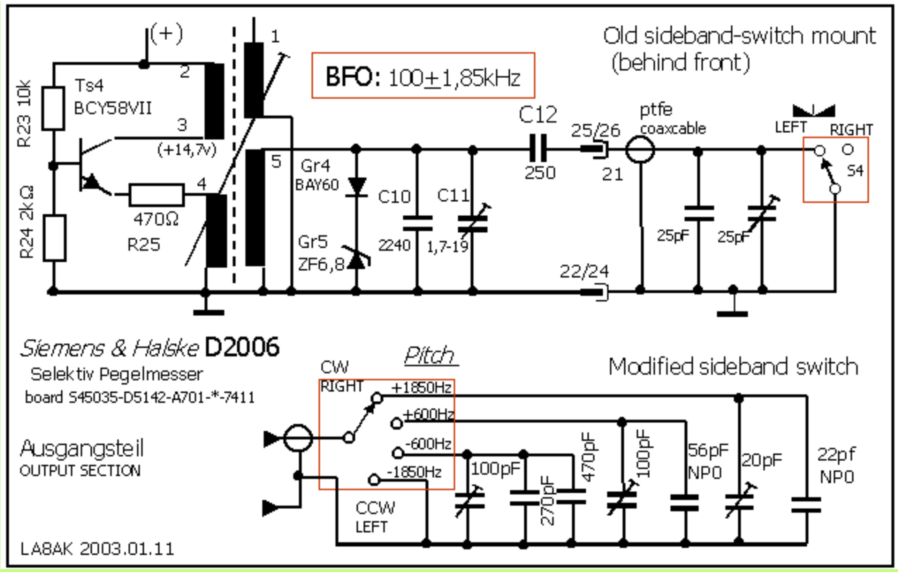
#2.10) Very old LF selective level meter (Messkoffer)

TEKADE Träger-Frequenz Meßkoffer 5-155kHz (later German term is Selektiver Pegelmesser), Suppose this is the first selective voltmeter ever made. They were used to measure levels on multi-channel carrier frequency systems. One such instrument were placed in Kristiansand, another in Arendal since it was subsea coaxial cables to Denmark, believe it was 8 or 15-channel systems (ME8 & MG15) during the war and many years after. See Die deutschen Funknachrichtenanlagen Band2 "Der Zweite Weltkrieg" pg139

See chapter M22 for more info about old instruments.

#2.11) Siemens D2006 Selective level meter (Selektiver Pegelmesser)

The advantage with this instrument is that it is still easy to repair and modify.



Sidetone modification.
The problem with many of those Selective Level meters is that the pitch is meant for somebody else, but not hams.
It is far too high for CW reception, for this unit it is 1.5kHz (some other instruments may have 1850Hz). So you cannot use the lowest bandwidth to listen to a CW station, only for measurements, and must tune to lower pitch using wider bandwidth. When I listened to SAQ on 17.2kHz (Alexandersson Generator) last summer, the signal to noise was only 6dB or less, but I later discovered that it was some strong noise sources
just above this frequency, and if I could use the 80Hz bandwidth it would improve 30dB. It was therefore a good idea to open the handbook and start interpreting the German text. Soon it was discovered the solution here is quite simple, all the modifications are made behind the front plate, none on the actual board, you remove some components and install a swith with at least 4 posititions and a small board for trimmer capacitors with some fixed values in parallel. It was difficult - even when reading the book, to understand the proper way to open the instrument. Was it neccessary to take off the front? Yes, it was, and it seemed rather difficult first, but wasn't so difficult, when you learned about it, and I needed to remove it later, because I forgot some screws.....

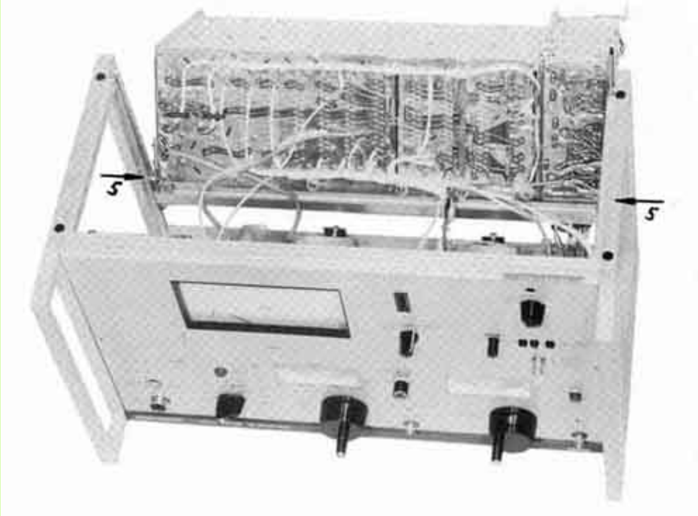
The board **S45035-D5142**-..(Ausgangsteil) has a simple product detector and BFO. The BFO frequency is tuned with 2250pF and it is shifted by S4, possibly shifting it 1.85 below and above 100kHz as the switch is set to left or right. when the 250pF is grounded it is LOW and when it has the external capacitors in series it is HIGH. The unmarked capacitors above the switch behind the front are 25pF styroflex and 25pf air trimmer, I measured 41pF, but don't always rely on the instrument, and to this figure you must add some 50pF for the PTFE-cable.
Remove all plates and screws and when you still can't find a way to get into the box, you must start reading the instruction book, Chapter 4, MAINTENANCE - only to discover that you can just as well put back some of the screws again and remove the upper unbrako type screws instead - to slide the upper unit backwards. It was a fight to remove the front plate, but it went after all. Careful with all those terribly small 2.5mm screws, nuts and washers!

Considered using varicap diode (BB112 or BB130), but it must be shorted for USB, it demanded a potmeter with an Normally-Open-switch and they are rare, so I decided use a switch with 4 positions instead.

Connected 3 trimmers and fixed value capacitors on a bracket with pcb laminate where the old capacitors had been.
The 4 positions are now:
1. Shorted coax cable as earlier CCW with 1850Hz pitch for 80Hz filter.
2. 470pf+270pf + 100pf trimmer - to tune one sideband with 500-800Hz pitch
3. 56pf + 100pF trimmer, to tune the opposite sideband with 500-800Hz pitch
4. 22pF + 20pf trimmer (or 10pf fixed and 40pf trimmer) for CW as before

used a six position switch, but couldn't think of the need to use more than 4 positions, didn't find any small swiches with long shaft, so the nut must protrude through the front plate, so the hole must be widened a little for the nut.

The audio output level is high enought to drive a 300ohm dynamic phone inset (+1dBm or 700mV)



Anweisung: Schrauben 1, 2, 3 und 4 lösen, Baugruppenwanne um Drehpunkt 5 kippen.

Servicing Siemens D2006 Level Meter, when you have unscrewed the proper screws amongst the many which seem much more likely to choose...

#2.12)

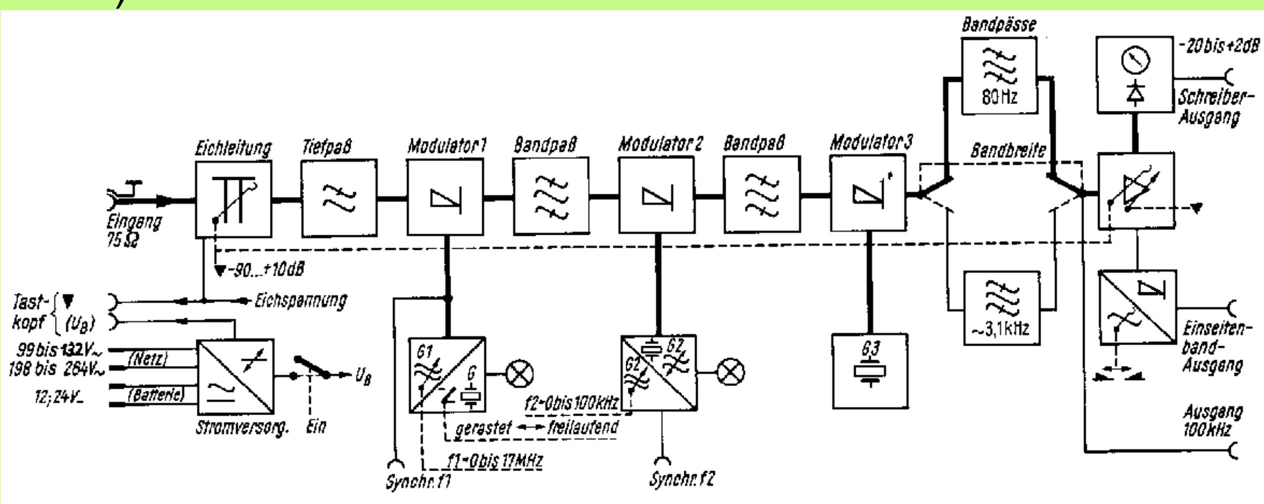
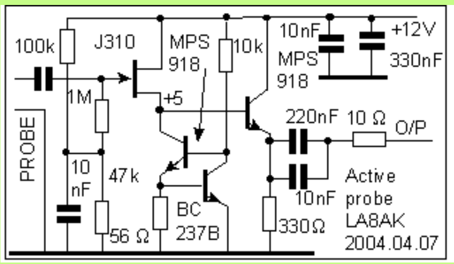


Bild 2 Übersichts-Blockschaltbild des Pegelmessers D2006

Siemens D2006 Level Meter.
Block circuit

#2.13) Active hi-Z RF probe for use with D2006 or other instrument

The probe under check connected to Siemens D2006 selective level meter (or other similar instrument)

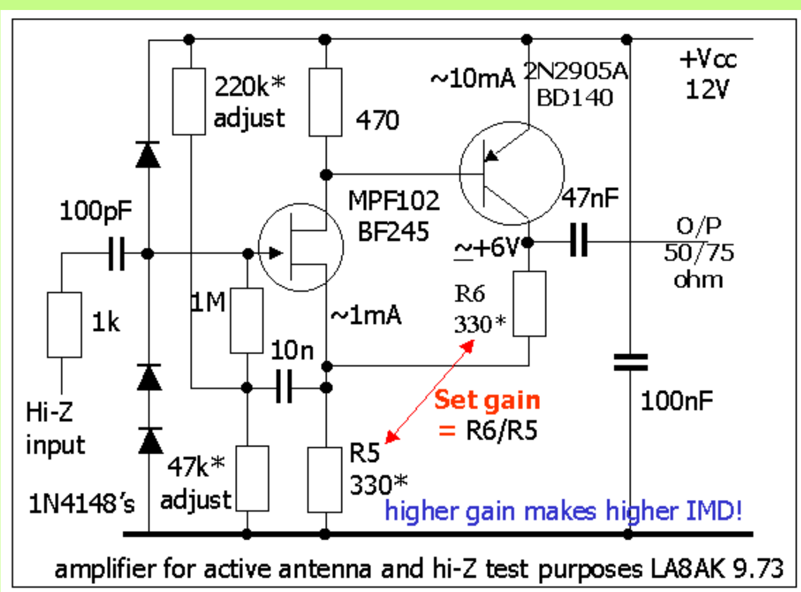


Circuit diagram for the probe. 1dB variation 50kHz-18MHz using Siemens D2006 Level meter (75 ohm), probe voltage loss: ca 1.5dB. The input coupling-capacitor is 100pF.

An alternative is the Maxim MAX4005 with frequency limit of 950MHz, but I needed the circuit today and don't want to wait for something I am not really sure if could find or how long it takes to get it. This device requires +/-5V supply.

[>.905. see block diagram for D2006 Pegelmesser (too large to display on this page)]

#2.14)



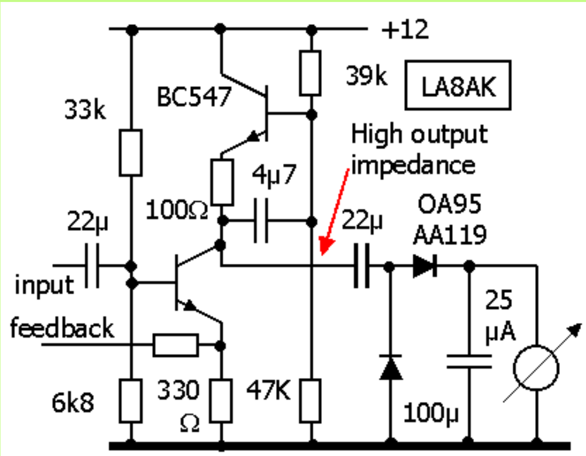
General purpose high input impedance amplifier was designed by LA7MI in 1973 for use as active antenna. It is important not to use more gain than neccessary, also the positive feedback to the input, should be done with care, and avoided if not definitively neccessary. We used it for a while, but I had some intermodulation problems with a local BC-station, it was later used with a general coverage frame antenna covering 0.5-4MHz without any problems. It is a simple circuit for some test purposes

---

#2.15)

Linear RF detector

I've wondered what is the important rules to make a linear detector with conventional technique and germanium diodes It is described in Wandel&Goltermann SPM-3. The upper transistor operates as constant current source and at the same time balances the collector voltage for the first stage.



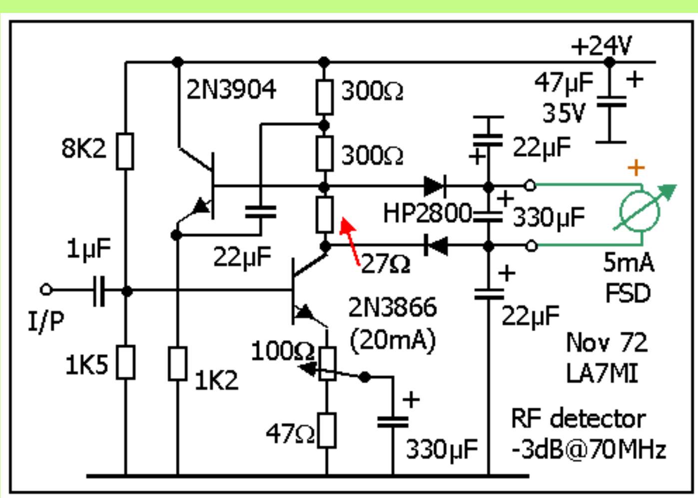
RF detector used in SPM-3 (Selektiver Pegelmesser)

SPM-3 (Wandel&Goltermann) is probably one of the most popular portable "Selektiver Pegelmesser/Selective Level Meter", it covers 0.5-612kHz and it is ideal for 136kHz measurements, it has built in chargeable batteries for portable operation (but they are most likely defective).
It is a matching signal generator - PS-3 - which may be controlled by SPM-3 for tracking on the same frequency.

#2.16)

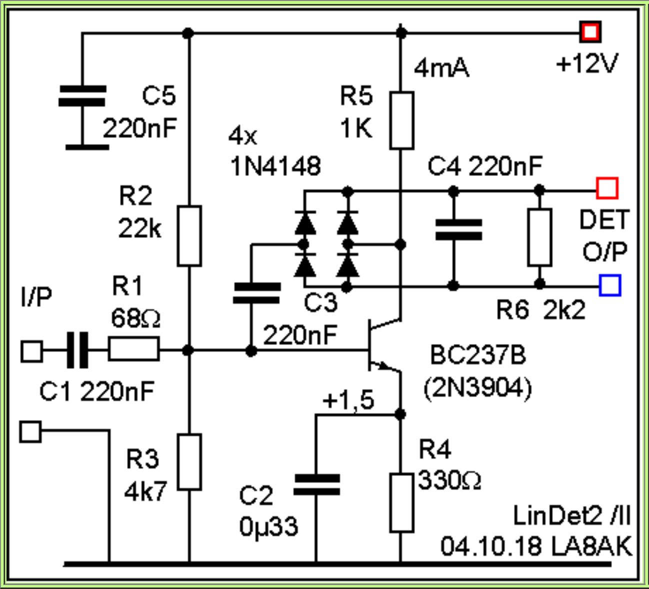
RF detector.

This is based on techniques found in HP-651B, but increasing the current through 2N3866 (BFR96) to 20mA LA7MI discovered that the frequency limit increases, -3dB limit was measured to 70MHz, it was used in his broadband RF millivoltmeter, constructed in November 72 - covering 360Hz-36MHx with 0.7dB variations. I is of course an old design, but sometimes once may still find such circuits useful, it is several other devices which simplifies operation like NE/SA604/614, TDA1576 etc.



HP651B detector circuit

#2.17)



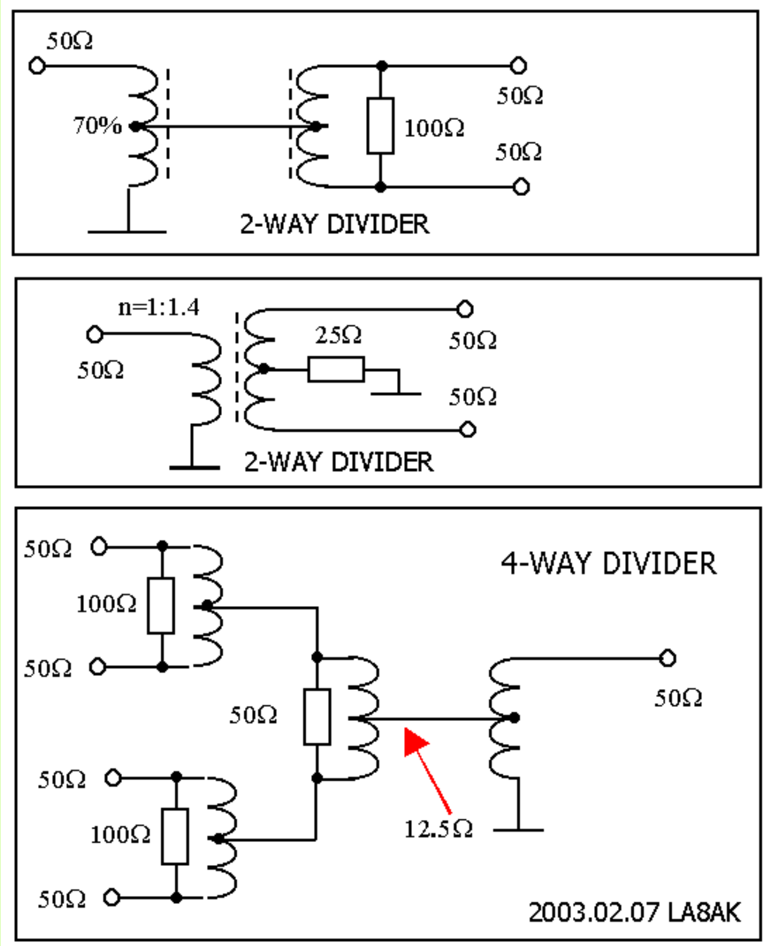
Another linear detector which isn't so critical for matched diodes, almost any smallsignal silicon diodes may work has been tested in the range 50-5000kHz, but I am not quite certain about all the critical factors.

Level.	-10dBm	-20dBm
50kHz	2.0	0.608V
190	2.05	0.654V
300	2.05	0.657
490kc	2.05V	0.660

Measured with WG PS-3 and Fluke 8020B DVM

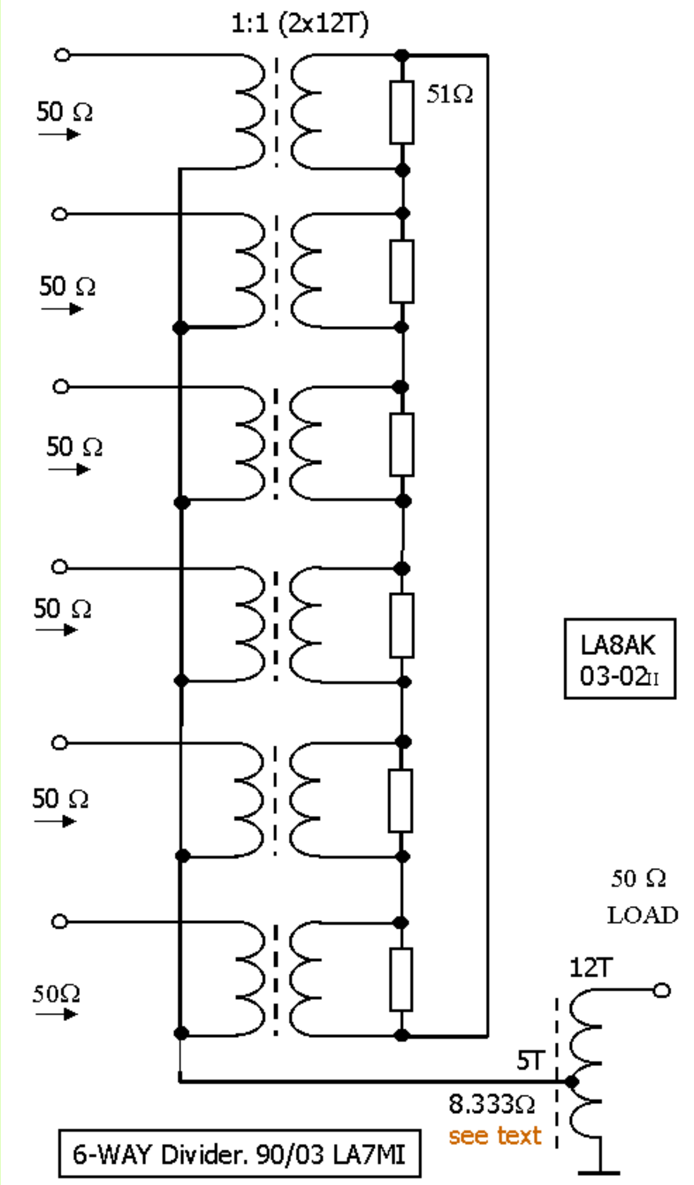
The detector may well be connected to a 1mA FSD 2kΩ meter

#2.18)

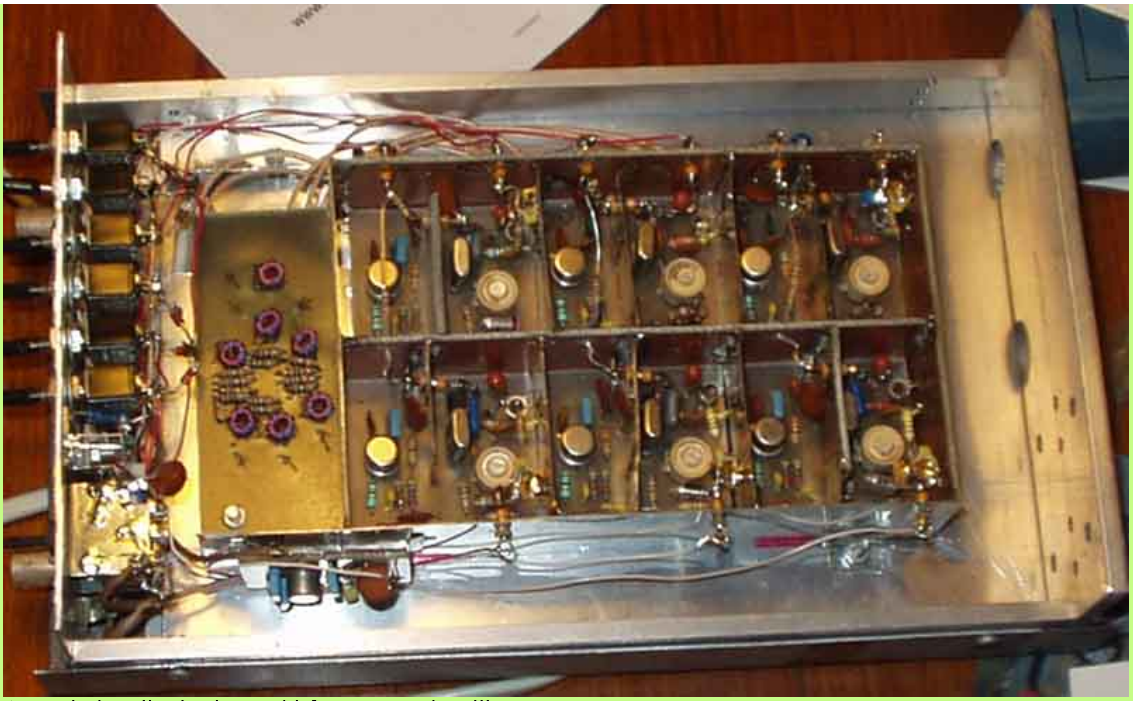


2-way divider (LA7MI)

#2.19)



6-way divider (LA7MI)



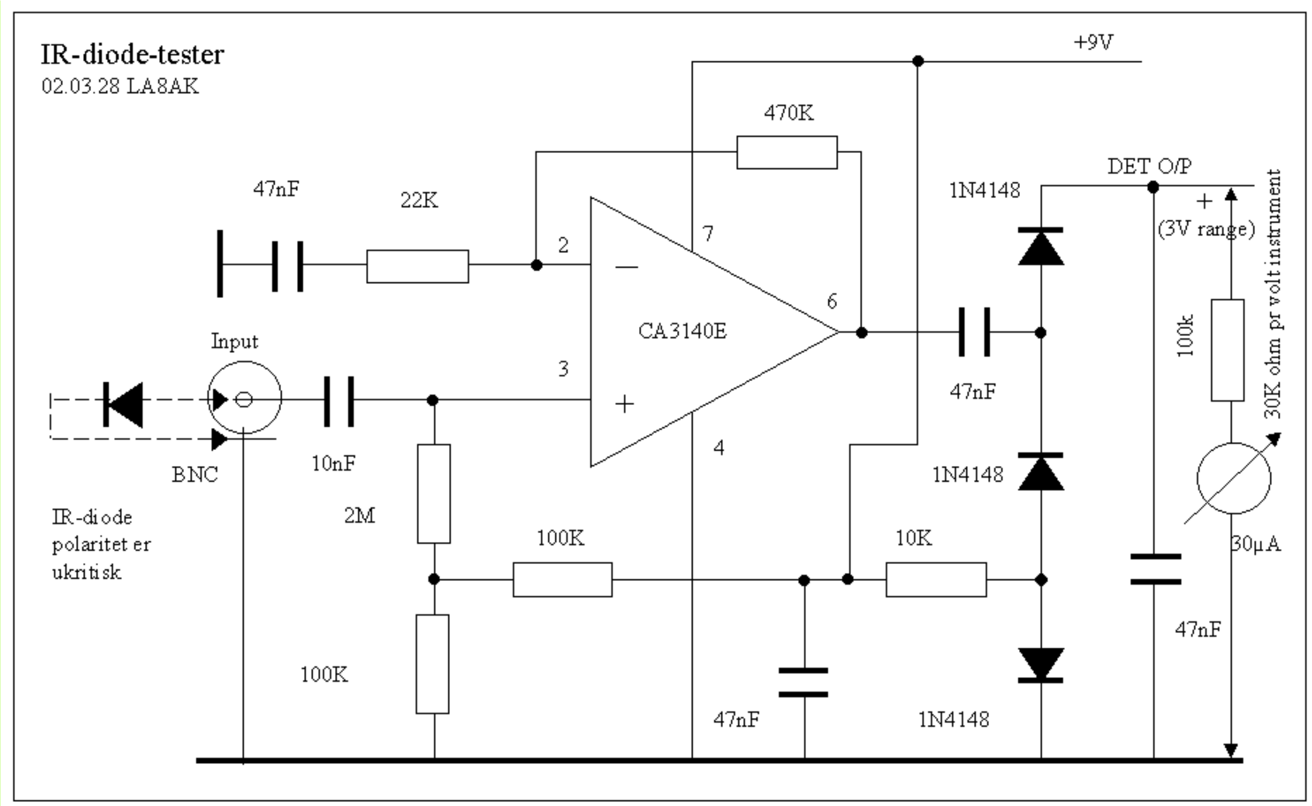
A practical application in a multi-frequency xtal oscillator

Power dividers: See 32. Weinheimer UKW Tagung, Scriptum der Vorträge 1987:
Leistungsteiler für VHF/SHF (DJ1EE):
1) Hybride Leistungstrafos, breitbandig KW-UHF
2) 3dB Richtkoppler (Koaxial bzw. Streifenleitungstechnik)
3) 3dB Branchkoppler (Planarer Streifenleitungstechnik)
4) Mehrwege- Wilkinsonteilr (Planare Streifenleitungstechnik)
Leistungsteiler/Addierer nach Wilkinson, Spannungsverstärkung der Einzelverstärker,
Breitband-Wilkinsonteiler (144-432MHz)

Booster amplifiers, see page-L2 or c14

#2.20)

It was a problem to find 2m signal generator with sufficient stability for ssb/cw 25 years ago, while an RF generator was easier to get. Here is my up-converter using SBL1/SRA1. The oscillator with 43.333Mhz xtal produces 130MHz to mix with 14MHz from the generator, to give a signal on 144MHz. The mixer has 7dB loss. To make it easy, I added attenuator on the input and output for total 20dB lower level than the level generator has. To convert from dBU (600 ohm reference level, 0.775V = 0dB) to dBm (50Ω) you must add an attenuator of 10*log (R1/R2), where R1=600Ω. And if the generator has 75ohm impedance you could use a minimum-loss-pad.



IR test receiver - to test IR transmit diodes, any IR diode will work, I used a transmit diode for my receiver

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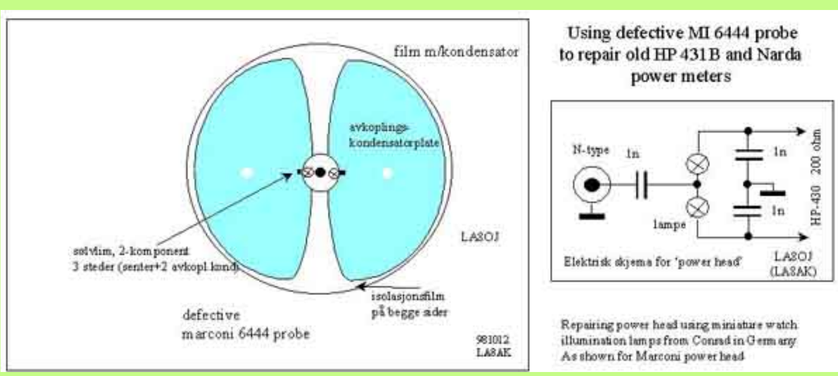
#2.21)



LA8OJ used defective MI SHF power meter heads to make his own probes for NARDA microwattmeter using subminiature lamps

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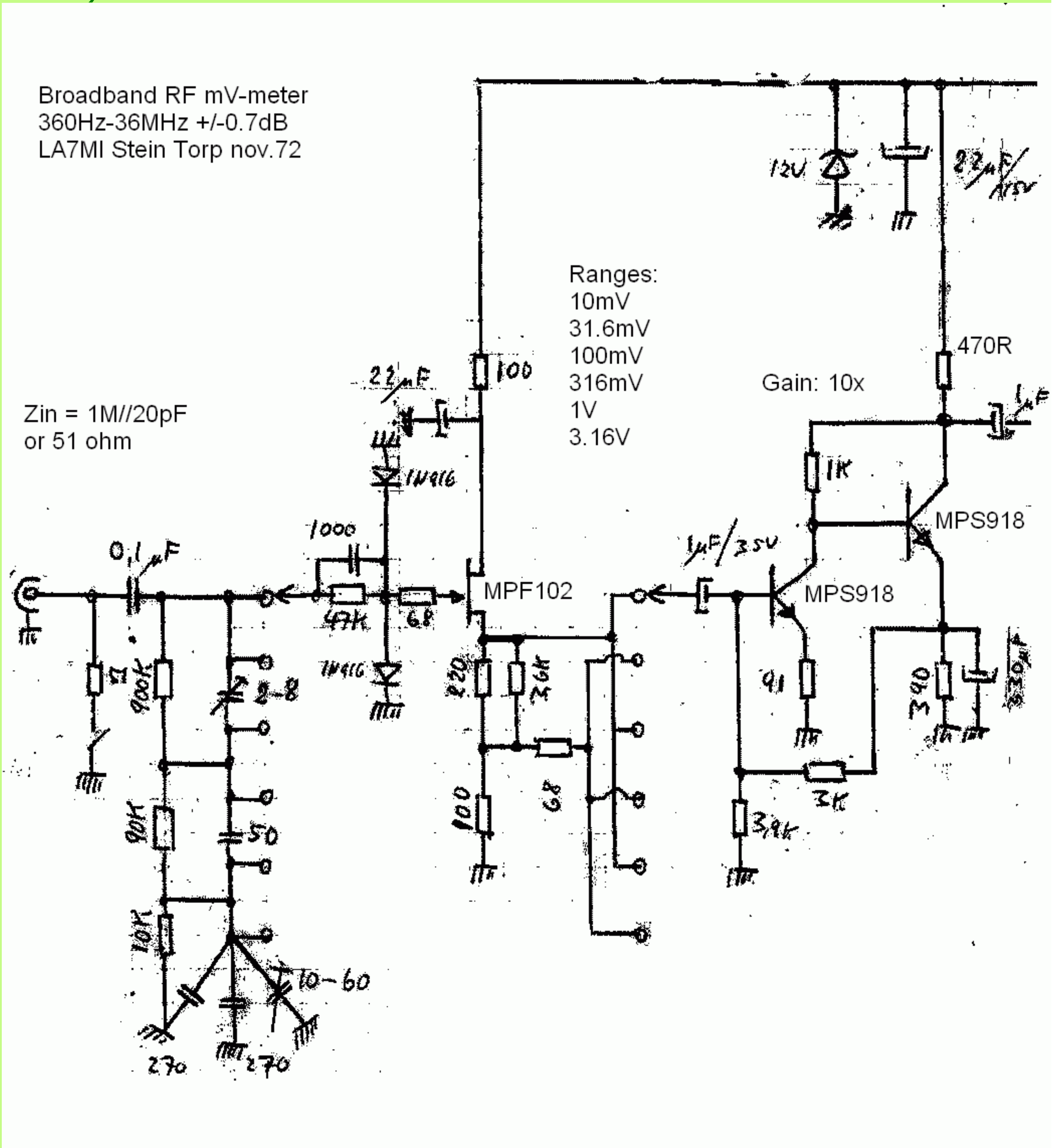
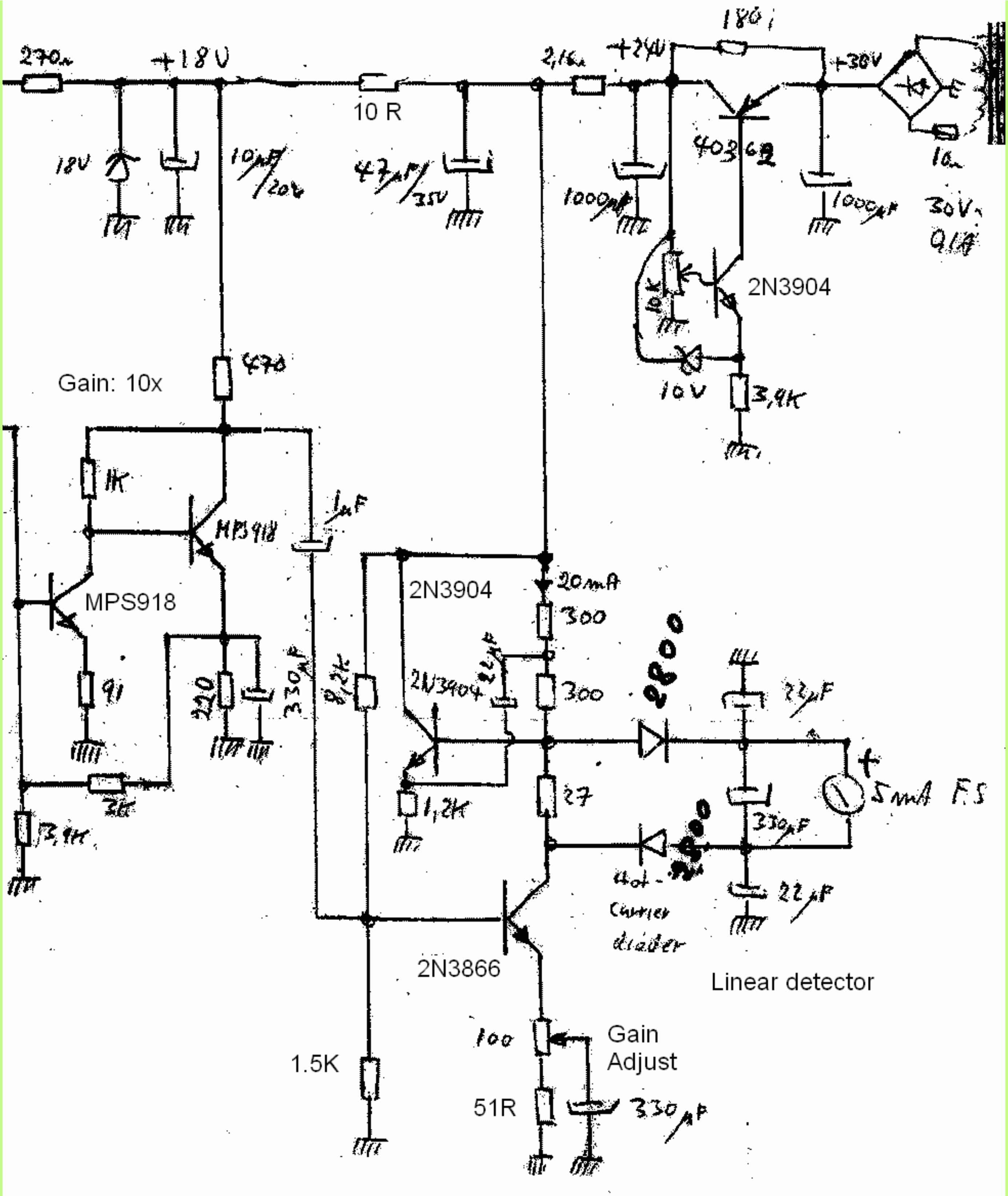
#2.22) LA7MI 360Hz-36MHz broadband level meter.

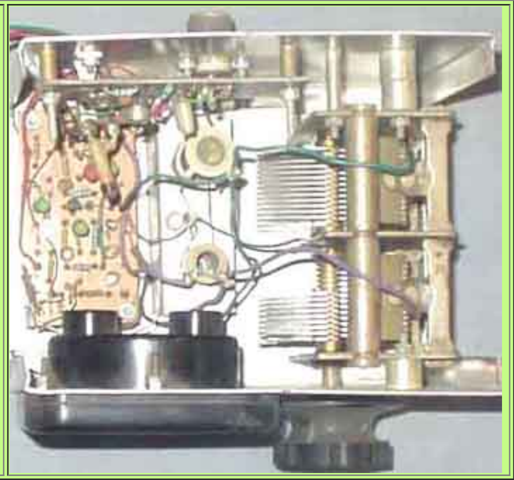


LA7MI linear broadband RF mV-meter (Circuit diagram Part 1)



Part 2. Linear RF mV-meter
Some "Pegelmessers" have a selection for broadband, this is useful for several measurements, but usually this is only available for instruments covering up to 600kHz. Here is shown a broadband level meter covering from audio to 36MHz, and with some inaccuracies further up.
Many IC's are available for RF detectors, but they are not linear. A linear instrument has apprx 20dB ranges, but 10dB covers most of the scale.
Believe the circuit diagram of the RF detector was found in HP651 signal generator, but it was improved with higher current.
The rectifier delivers 30V DC

#2.23) *'Selective'* RF level meter



"Selective" RF voltmeter for HF (two ranges) built in 1982 (described in Radcom)

N2PK's Amateur Radio Projects Page

[Vector Network Analyzer (VNA)](#)

[Nolan Lee's site for tube testers](#)

Old instruments and tube testers, see http://www.one-electron.com/FC_TestEquipment.html

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Email: [redacted]

BACK

Last update: 2004.10.18

Crystal Radio Lesson Plan
Overview
We will be spending the next two weeks building a working radio from scratch! We will try various materials and tweaks and see who can pick up the most radio stations.
Materials (per radio)
Tutor supplies:

- Exacto-knife to strip the wire and cut holes in the toilet paper rolls
- Wire cutters
- Masking tape (to help hold the wire in place if the kids have problems winding it)

Week 1: The radio
Student supplies

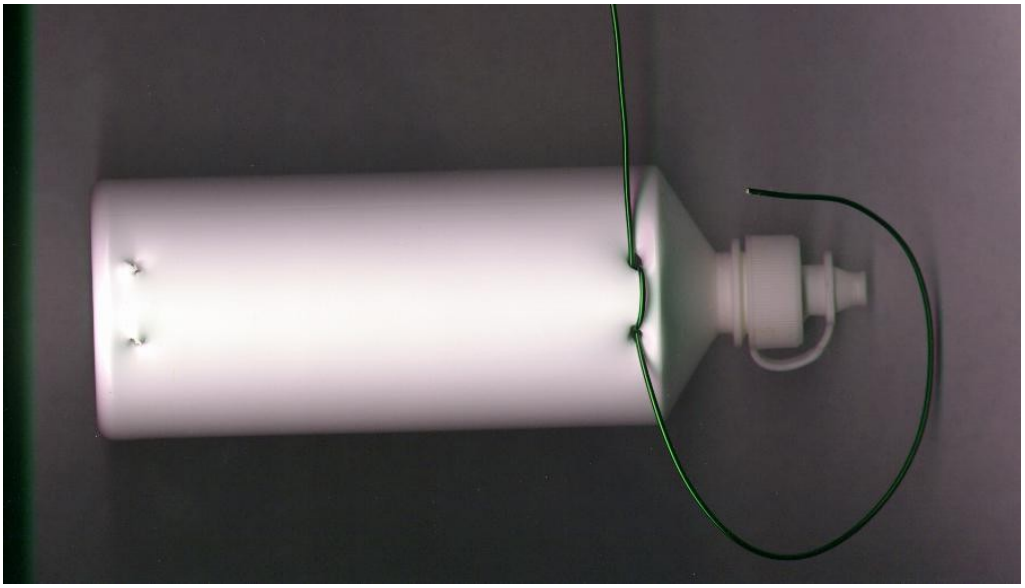
- 4 alligator jumpers
- 1 cardboard tube, like from a toilet paper roll or similar size
- Something to “ground” the radios with. Either a metal stake or the green cable from a 3-pronged power plug, for example.
- 1 germanium diode, (official designation 1N34a)
- 1 piezo-electric earphone (e.g. from Jamesco)
- 1.75” diameter * 100turns * 3.14 = 45' of enamel-coated magnetic wire, 20-26 guage (50' to be safe)
  OR
- 50' of regular solid copper wire, 18-22AWG

Week 2: The tuner

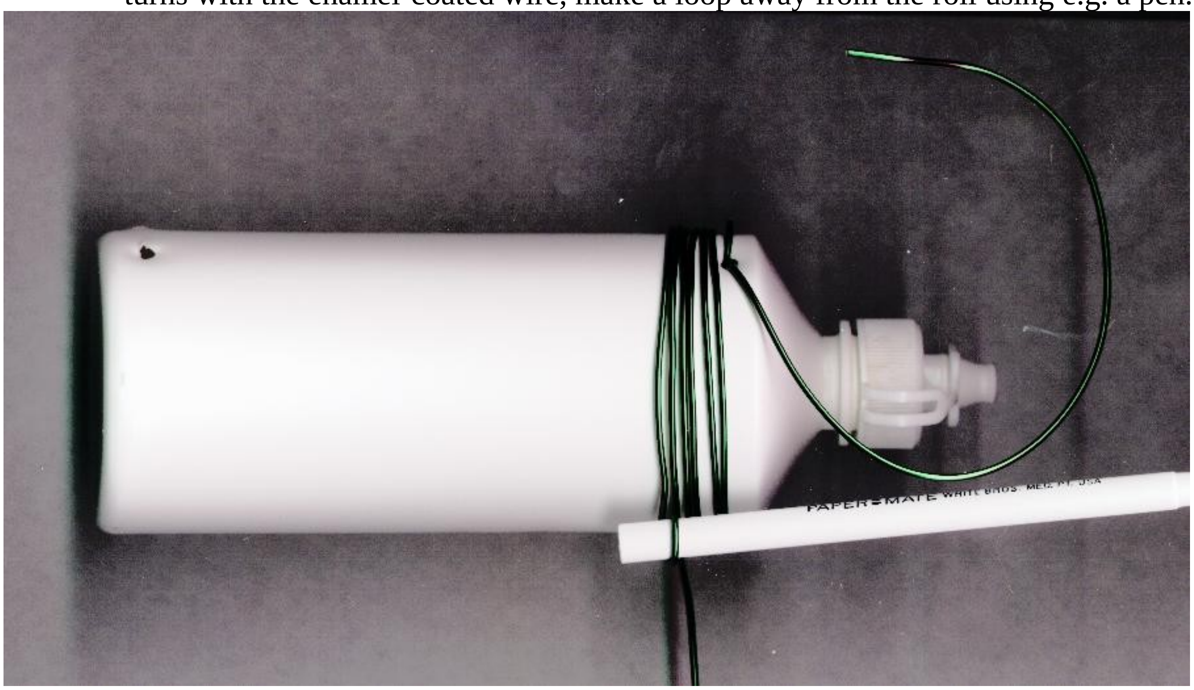
- 1 cardboard roll, like from a paper towel roll or similar size
- enough aluminium foil to cover the cardboard roll
- 50 ft enamel-coated magnetic wire, 20-26 AWG
- radio from week 1

Lesson plan

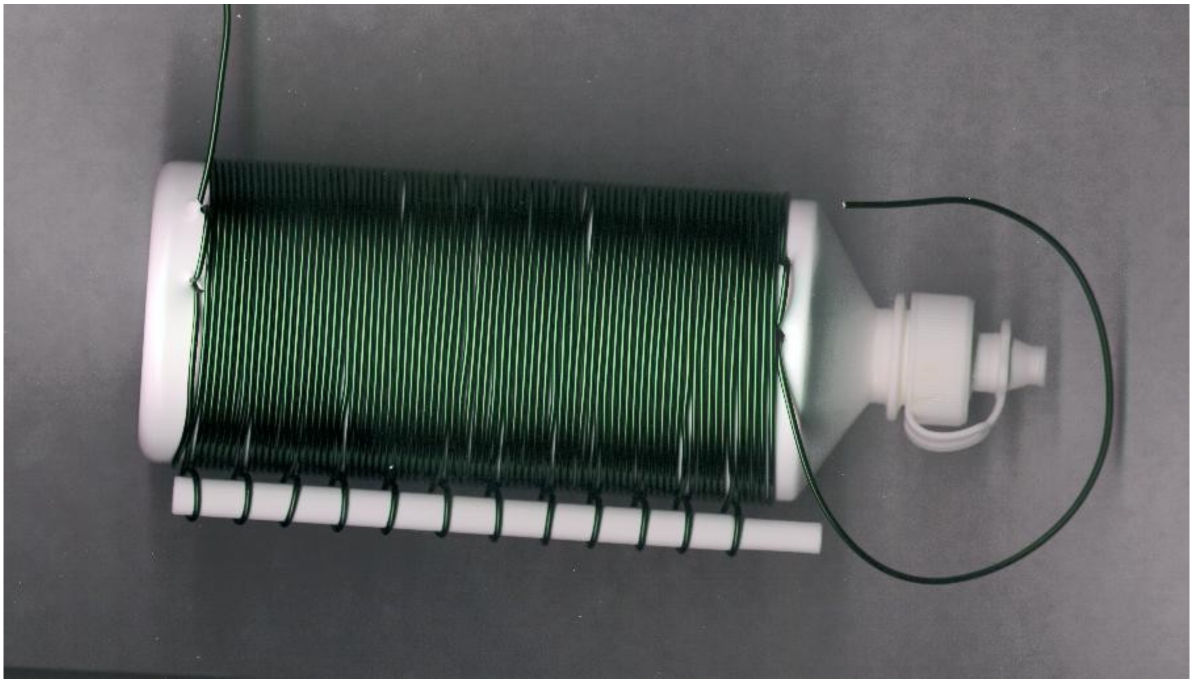
- Introduction, week 1
  - Does anybody know how a radio works? Look for EM radiation, antenna, tuner.
  - Explain Faraday's law, that's how our radio will get its energy.
  - This week we will be building an antenna and plugging in a speaker to it.
  - Next week we will make a device to tune the radio so that we only catch one station.
- Materials hand-out
  - Ask the kids which wire of the two we bought they think will be able to catch the electric waves in the air the best.
  - Ask whether they think the number of loops will matter, assign each group a number of loops from 50-150.
  - Ask whether they think how close together the loops are on the cardboard matters.
- Building the radio
  - Split the kids up into e.g. pairs. In each pair, one person will be in charge of winding the wire, the other will be in charge of counting the turns.
  - Steps:
    - Tutor pokes two adjacent holes in the sides of the paper towel roll near each of its ends.



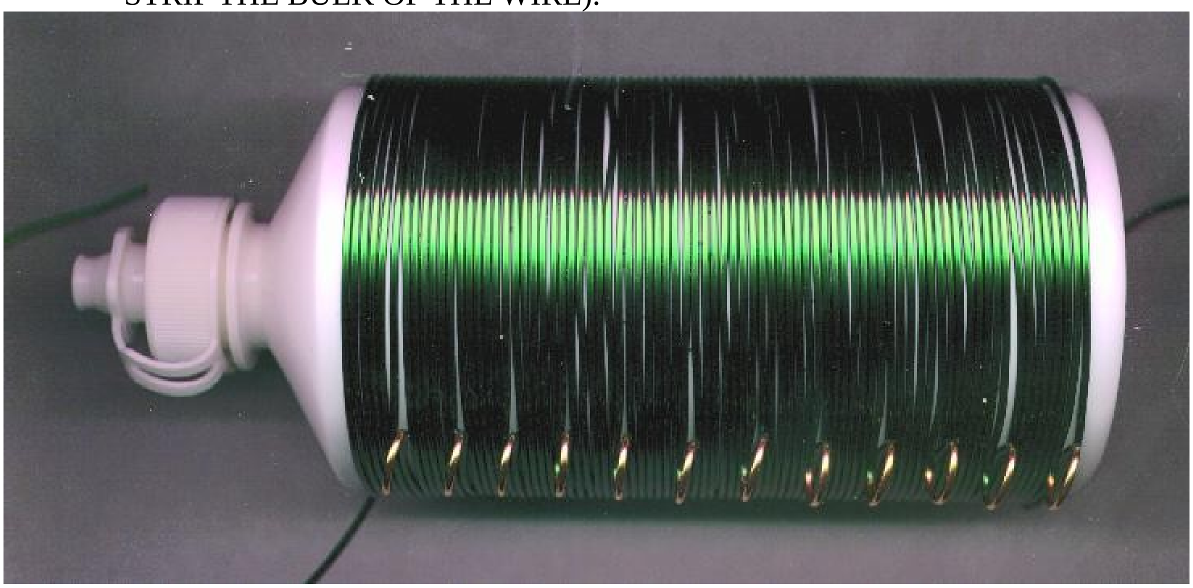
- Thread the wire through the holes to anchor it there. Make sure to leave a few inches of wire hanging out.
- Now wind the wire around the paper towel roll. After 5 turns with the copper wire, or 10 turns with the enamel-coated wire, make a loop away from the roll using e.g. a pen.



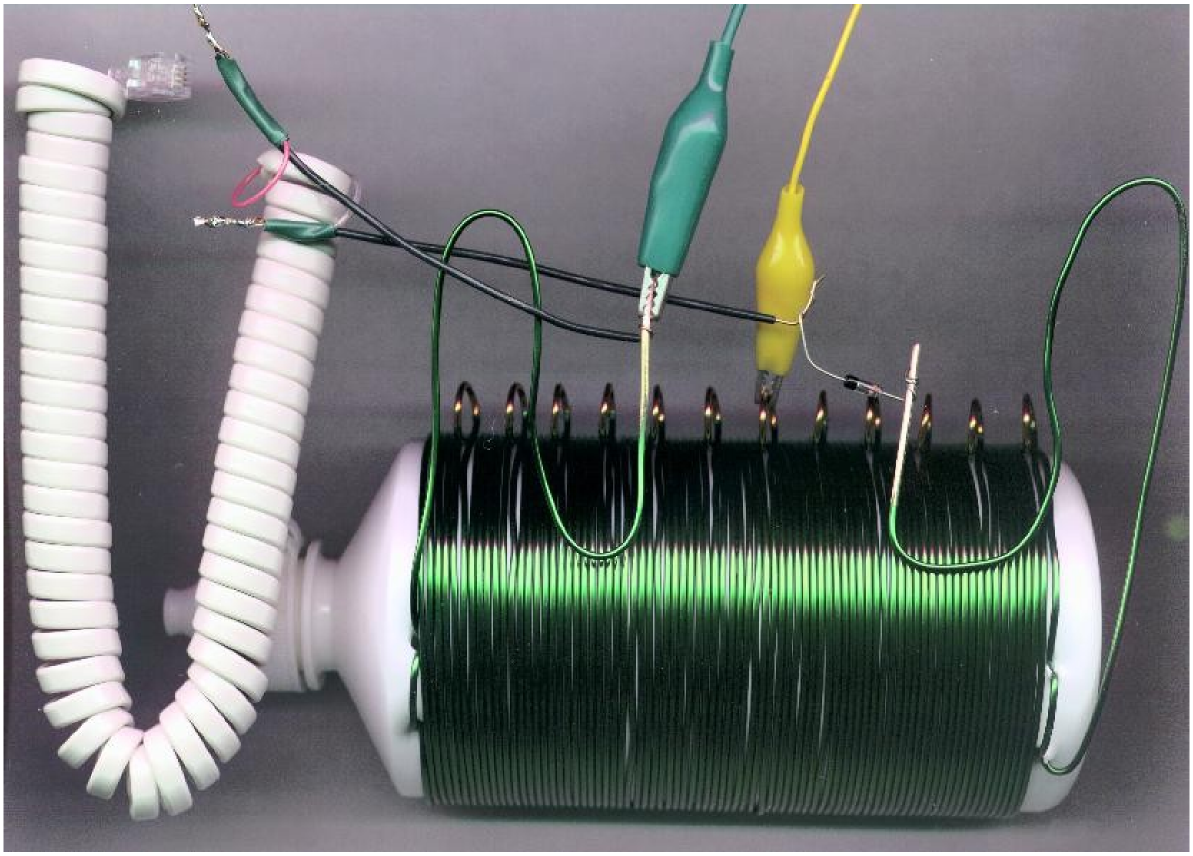
- Continue until the assigned number of turns has been reached. If necessary, the tutor should cut holes near where the wrapping stopped so that the kids can thread the wire through them. (e.g. if they finish wrapping and are only half-way across the roll). Make sure to leave a few inches of wire hanging out.



- Now the tutor should strip the loops of wire that are away from the bottle (DO NOT STRIP THE BULK OF THE WIRE).



- Finally, the assembly. See wiring diagram below for overall schematic. First, attach one jumper to the ground and then back to one end of the roll's wire. Now clip another alligator lead from that same end of the roll's wire to the headphone. Clip another lead from the other wire from the headphone to either end of the germanium diode. Now, if you have the headphone in your ear, pinching together the other end of the germanium diode and free end of the roll of wire should let you hear all radio stations that your radio can pick up! Finally, if you have a spare radio antenna, clip the last alligator clip from the antenna to each of the loops to make a primitive tuner.



    - Next week, the tuner!
  - Testing
    - Have kids decide which wire worked better, whether more turns is better by listening for volume changes.
    - Try to chat with them about why it works better when you pinch the wires with your fingers instead of just touching them together.
- Cleanup
  - Make sure to save the radios for them to continue next week!

(Fairly) Simple 75M SSB rig with PTT

NOTE: The original simple SSB presented on this page has been replaced by an improved design. These changes increases the total parts count some, but are well worth it. The improvements include active MOSFET QSK switching instead of a passive, series L/C with clamping diodes. This improves receiver sensitivity and eliminates possible IMD caused by strong signals clipping in the diodes. The Audio muting scheme has been changed. T/R switching has been improved to eliminate spurious outputs during T/R switching. Filter termination has been added to flatten out response of the crystal filter. A second tuned circuit has been added to the transmitter mixer output. The Mic input has a high pass filter added to eliminate possible low frequency hum pick up when using a speaker mic. The transmitter circuit has been improved, allowing for more drive and power output. The circuit board layout has been improved to maximize the amount of ground plane and to incorporate the circuit changes.

Introduction:

Nearly all the simple SSB rig designs you will find use relay or mechanical switches to go between receive and transmit. Relays use extra power and take up a fair amount of space. They can also be expensive. Mechanical switches don't use power, but also take up a fair amount of space and often have to be located in inconvenient mechanical locations to minimize lead lengths. They also make the rig harder to use. The solution is to use electronic switching. Often this is done with diodes or bi-directional amplifiers. Both of these approaches can get complicated. The approach used here is to use a 74HC5053 analog switch and it works well. Two sections of the analog SPDT switch are used to toggle the crystal filter between the inputs and outputs of SA612 mixers. The third section switches a by pass cap between the inputs of the mixers, depending in which direction their being used for.

Transmitter chain:

The output of the Tx mixer is buffered by a 2N4401 emitter follower to drive the low impedance input side of a 10.7 MHz IF transformer. The transformer is returned to 75 meters by an additional, external 330 p cap. A second IF transformer is used to make a double tuned band pass filter, although for 75 meters, a single tuned circuit would be sufficient, as the IF and LO are far removed from the transmit signal. The output of the band pass filter is amplified by Q9 and further amplified by Q10 to provide sufficient voltage swing to drive the gate of the IRF-510 PA. C47, a 100p cap has been added from the collector of Q9 to ground, which eliminated some spurious outputs at some drive levels. Power output of 5 to 6 watts is produced by Q10, the IRF-510. Power output is greatly influenced by the match presented by the low pass filter. Minor adjustment of the spacing of the wire used to wind the low pass output toroid will make significant changes to the power output. Therefore, the spacing of the turns on these cores should be done to produce the best power output. Power output will vary with frequency, with about a 1 watt variation in a 200 kHz tuning range. Therefore, the tuning range and LPF should be optimized for the segment of the band you wish to primarily operate in.

Matching Crystals:

Closely matching the crystals for a SSB rig like this isn't as important as it would be for a CW rig. You can probably get away with out matching them at all. However, if you do have a frequency counter and a test oscillator to use, matching the crystals to with in 100 Hz or so isn't a bad idea. The crystals can be the inexpensive microprocessor type, either tall or short can, available from Mouser and Digi-Key by various manufactures.

Receiver:

The receiver input signal first passes through the transmitters low pass filter and then into the QSK switching FETs. During receive, Q2 is turned on, allowing the signal to pass through it to the receiver input. During transmit, Q2 is turned off, disconnecting the receiver input from the LPF. In addition, Q4 is turned on, shunting any leakage through Q2 to ground. Q5 is used as an inverter so the proper logic levels are applied to the gates of Q2 and Q4.

The input signal is then mixed with the LO in U6 to produce the IF of 9 MHz. The mixer output is routed through the crystal filter with U5 and into the product detector U4. The resulting audio signal is amplified by U3b and passes into the volume control. U2 provides additional amplification and drives the speaker. During transmit, audio is muted simply by shunting the audio input to U3 to ground using Q11.

MIC/PTT input:

If you use a speaker Mic, the mic can simply be connected to the MIC pad. Inside a speaker mic, the Electret mic is connected through a NO PB switch, which grounds the mic element. This causes a voltage drop across the mic, which is sensed by the U3a op amp to switch the rig into transmit. Some (if not all) speaker mics have a resistor across the mic element. If this is the case with your mic, the value of R4 will likely have to be reduced so that there is 3-4 volts across the mic element. The resistor across the mic element also reduces the output level, so it is actually better to remove the resistor from the mic and use the 22 K value shown. This will alllow you to get full power output with out the mic gain trimmer turned all the way up.

Separate Mic/PTT inputs:

Using the voltage change across the mic to switch to transmit can cause a spurious output from the transmitter as it switches on and off. This is because as the voltage across the mic changes, a voltage transient propagates through the coupling caps to the balanced mixer, causing it become unbalanced for a few milliseconds. To avoid this or to use a separate PTT input, the track connecting the MIC and PTT pads on the bottom of the board can be cut. In this case, a 22K resistor is used in R3 location. Now the mic is always on, so there is no voltage change across it. The rig is put into transmit mode by grounding the PTT pad.

VFO:

There are a number of options you can choose from for a VFO. The simplest being traditional analog techniques. A frequency range of 5.00 to 5.50 MHz is required for full 80 M band coverage.

There are two standard crystal frequencies available which will put the rig in the phone segment of the band, 5.068 and 5.185 MHz., producing an operating frequency of 3.932 and 3.815 respectively. 3.815 would probably be the better choice. By using a VXO circuit, the frequency could be pulled somewhat, though with 5 MHz crystals, it wouldn't be too much.

A simple and surprisingly stable VFO (PTO) can be made from a brass screw and a Nylon threaded spacer. I used a 1" long, #6 nylon threaded spacer. A longer one might be better. Find the longest #6 brass screw you can find, at least 1 1/2" long. Cut the head of the screw off and put a short 1/4" diameter #6 round brass spacer on the end of the screw and solder it on. Now you have something to attach a knob too, with out it being all wobbly. Construction details can be seen in the photo at the bottom of this page.

The PTO is built into a box made of copper clad board. The PTO coil is supported on the back side with another #6 screw. A #6 brass nut is soldered to the copper on the front side, where the tuning slug (screw) will go into.

To wind the coil on the Nylon spacer, if its a hex spacer, put a little notch near the front and rear of the spacer in one of the sharp edges of the hex. Put the wire in the notch at the beginning and end of the winding. A short screw in the spacer can be used to hold the wire ends tight. Once the coil is wound, cover it with a layer or two of epoxy cement to hold the wires in place.

I built the oscillator and buffer circuit on to a separate piece of singe sided copper clad board. "Island" pads were cut from the copper to mount the parts on. The board is mounted into the box with short stand offs. This reduces any capacitive coupling from the circuit to the rest of the box which might affect drift.

The oscillator frequency is set by the series value of L1+L2 and C2//C3. Since I couldn't wind enough inductance on the nylon spacer to use with the 560p caps, L2 was added. This also has the advantage of providing a means of setting the VFO frequency, with out having to add trimmer caps. Simply change the spacing of the turns on the core. It might be a good idea to start with an extra turn or two on the core, as the actual frequency can be influenced by how the circuit is built and parts mounted.

I used polypropylene caps for C2 and C3. NPO or C0G could be used instead.

C4, L4 and C5 form an output filter to remove harmonics and adjust the output level to something suitable to drive the SA612 mixer. The 1K resistor terminates the filter, ensuring proper operation.

Construction:

A printed circuit pattern, component location overlay, hole drill size diagram and parts list with supplier part numbers (sorry, haven't had time to make up the parts list yet) are provided in separate pdf files in a zip folder which can be down loaded here: ssb80_files.zip

To print to scale from the Adobe pdf reader, in the print set up menu, **unselect** "fit to page" and **select** "print image".

Note that the board tracks are through board view. If you use toner transfer sheets to make boards, you can print onto the sheet as is and the layout is reversed when you do the transfer. If you use photo sensitized boards, you need to reverse the image by putting the printed side against the board.

When soldering the components, be careful not to short to the ground plane surrounding most of the pads. Be sure to use sufficient heat when soldering components to the ground plane, as thermal relief tracks are not used. Before soldering in U5, note that a point to point jumer is required under the chip, though this jumper could go on the bottom of the board. In all, there are seven point to point jumpers required on the board. The reason for using most of these is to ensure that the ground plane was not broken up or became isolated in places. Also note that two long jumpers are required to connect the holes labeled "+DC" together.

Tune up and adjustment:

The most critical adjustment is the BFO trimmer, C57. If the BFO frequency is too low, excessive carrier will leak through the SSB filter and audio high frequency response will be attenuated. If set too high, low frequency audio response will suffer. A trimmer from the parts supplier is set to maximum capacitance. Give the trimmer about a 1/4 turn to set the capacitance to mid value. Connect your VFO to the board, a speaker, antenna and finally DC supply and turn on the board. Assuming no other problems to track down, you should be able to hear signals when you tune around the band. Peak T1 for best signal strength. Find a SSB signal to listen too and tweak the BFO trimmer to give the best signal clarity.

Transmitter:

Disconnect power to the board and insert a DC amp meter in series with the supply. Turn the PA bias control trimmer to full counter-clockwise. Connect a RF power meter and 50 ohm dummy load(min10 watt) to the antenna. Re-apply power. The board can be put into transmit mode by using a clip lead to ground the MIC input. Note the current being drawn by the board. Now turn the PA bias trimmer clockwise until the board current increases by about 10 to 20 ma. Be careful not to exceed this. It is possible to fully turn on the PA, at which point it will suck as much current as the supply will deliver. If the supply is not current limited in some way (electronically or with a fuse), either the PA or the power supply will fry.

The transmitter band pass filter, T3 and T4 can be peaked by re-adjusting the BFO trimmer to maximum capacitance. This will allow some carrier to pass through the crystal filter. With the MIC input grounded, adjust T3 and T4 for maximum power output. Once this is done, re-adjust the BFO trimmer so power output just goes to zero. This will likely be the best BFO setting.

An alternative way of peaking T3 and T4 is to insert an audio tone into the MIC input. A 10K resistor will have to be placed between the MIC input and ground to switch into transmit mode. A 1000 Hz test tone with adjustable level would be ideal. Leave the MIC gain set to mid setting. Adjust the tone level to produce some

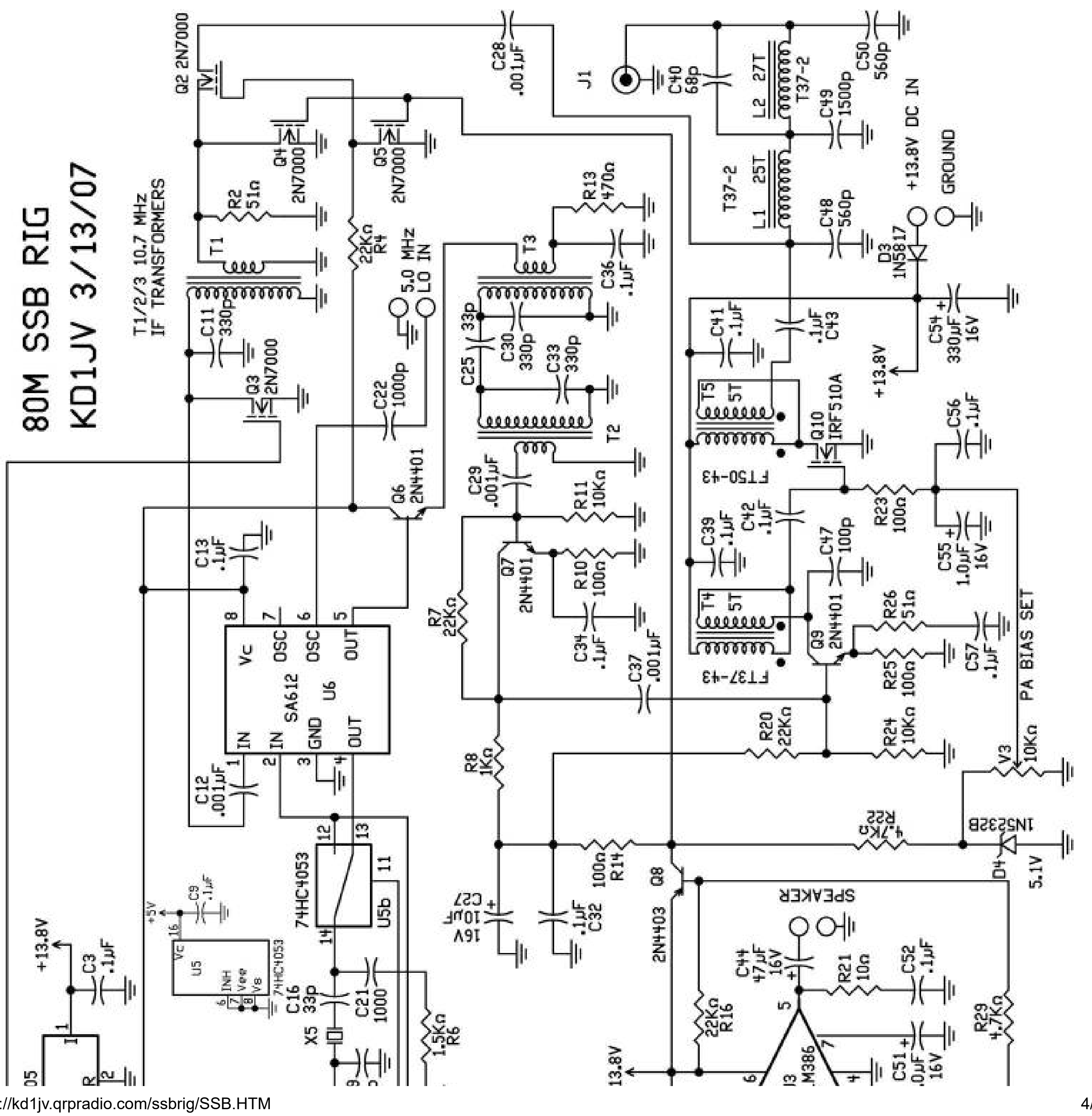
power output and peak T3 and T4. Now increase the tone level until power output no longer increases. At this point, you can tweak the spacing of the turns on L3 and L4 in the output low pass filter for best power output. Doing this can make a remarkable improvement in power output by optimizing the matching between the PA and load.

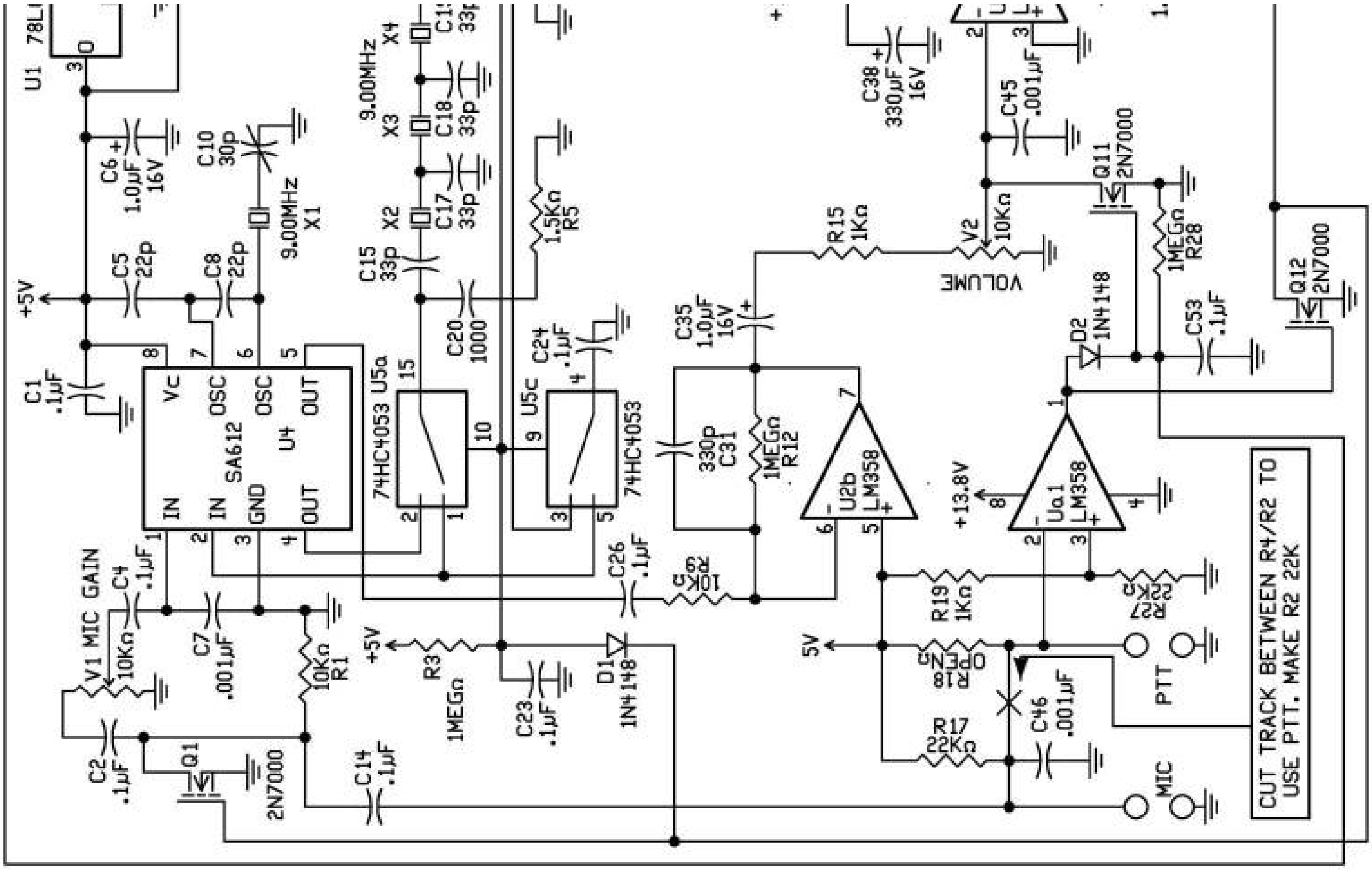
MIC gain adjustment:

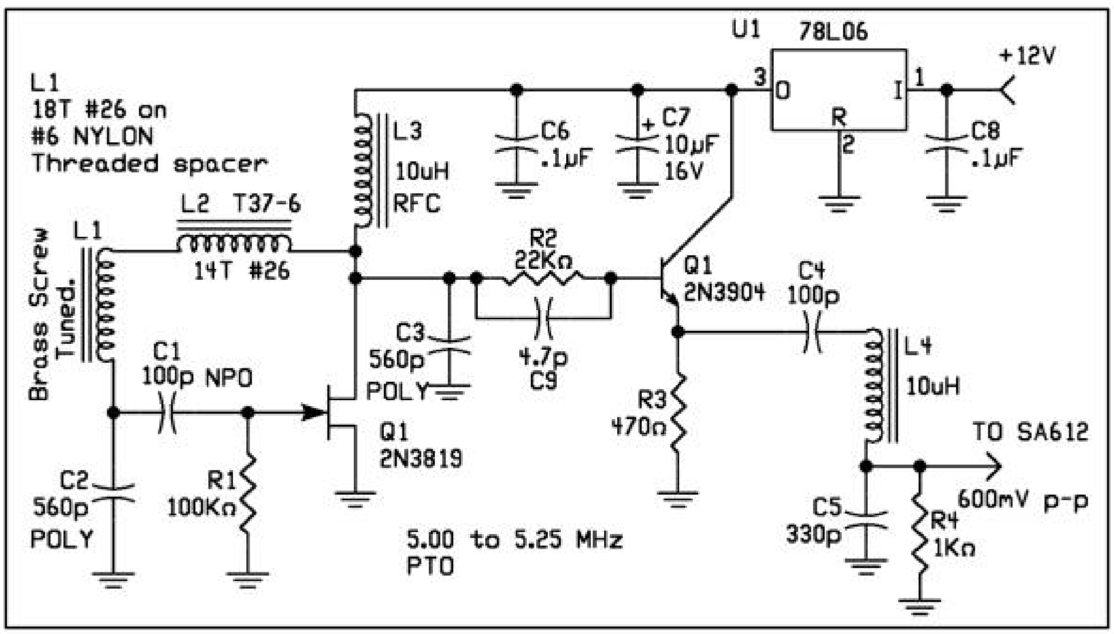
Setting this control can be a little trickier too. Too much gain and the signal will distort, while too little will result in low power output. The power you see on an average reading watt meter when using normal speech should be about 1/3d that which is seen when you whistle loudly into the mic. The best way to set the gain is to look at the output with a Scope and make sure it looks like the pictures you see in the Handbook.

73, Steve KD1JV

Main board schematic







5.00 to 5.5 MHz, brass screw tuned PTO

Close up of PTO assembly. Back and Right side removed for access. Wax may be melted over parts for additional mechanical stability

Three Technologies for Harvesting Ambient Energy

Consumer devices will run longer by pulling power from the environment

Posted 20 Mar 2015 | 19:00 GMT

By **ALFRED POOR**

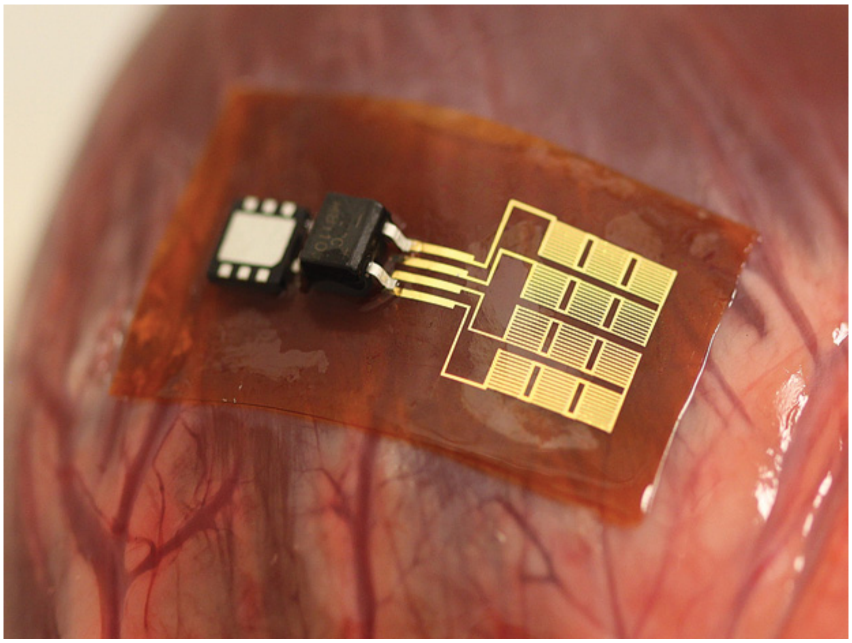


Photo: University of Illinois College of Engineering

Pulse Powered: A piezoelectric harvester is shown attached to the surface of a bovine heart. The conformable design can harvest enough energy for a pacemaker.

We are entering an era when scavenging tiny amounts of power from the environment can power small devices to do extraordinary tasks. The needs of the Internet of Things and the advent of lower-cost components are moving energy-harvesting systems from niche applications to broad-scale practicality.

This was the clear message of a conference sponsored by market research firm IDTechEx (http://www.idtechex.com/), held in Santa Clara, Calif., last November, where seven events took place at once. In addition to energy harvesting and storage, the topics covered were printed electronics, wearable technology, 3-D printing, supercapacitors, the Internet of Things, and graphene. These seemingly disparate fields are tightly linked; for example, as IDTechEx CEO Raghu Das pointed out, wearable devices were a strong driver for energy-harvesting technologies. Throughout the sessions and in the exhibit hall, other linkages were evident: Supercapacitors hold the potential to create highly efficient ways to store and release harvested energy, and 3-D printing plays a big role in creating prototypes and short-run custom production items.

According to IDTechEx's analysts, the energy-harvesting industry is projected to grow to US $2.6 billion by 2024. The harvesting show was built around three main sources of energy and the technology used to tap them: mechanical energy, heat, and electromagnetic emissions.

Photo: Southeastern Railways

Leveraging Locomotion: Fitted to a train, this device uses the vibrations of the undercarriage to cause a magnet to oscillate in a coil, thus generating electricity for sensors.

One means of harvesting mechanical energy discussed was a module created by the British company Perpetuum (http://www.perpetuum.com/). Its module harvests energy from the vibration of railroad car wheels: The vibrations oscillate a magnet in a fixed coil, powering sensors that monitor the temperature of wheel bearings. Southeastern Railways (http://www.southeasternrailway.co.uk/about-us/about/), based in England, has installed Perpetuum's system on all 148 of its Electrostar trains to identify and address small problems before they become large ones.

Energy from motion can be harvested by other means. A variety of materials exhibit piezoelectric properties: Apply a force and the material generates an electrical current (and vice versa). And new piezoelectric materials are being created all the time. For example, a University of Illinois graduate student has created a thin, biocompatible piezoelectric film (http://engineering.illinois.edu/news/article/8445) that can be implanted safely in living tissue. A multilayered device incorporating the film that is mounted directly on the surface of a human heart can power a pacemaker. This can eliminate the risk to patients that comes with surgically replacing a standard pacemaker every 5 to 10 years, when its batteries run low. Piezoelectrics can also work for larger-scale applications. During the 2012 Summer Olympics, in London, part of an underground station's walkway lighting was powered by passengers' footsteps across energy-harvesting tiles. IDTechEx estimates that the piezoelectric market worldwide was about $35 million in 2014, nearly twice the size of the market for 2013.

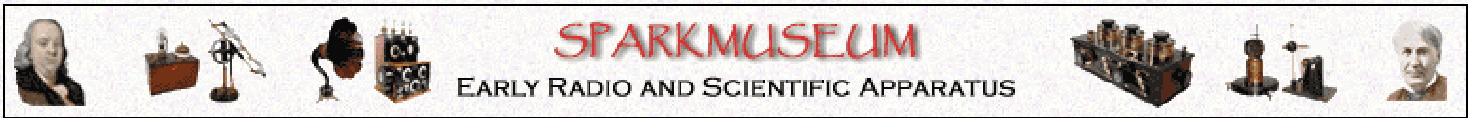
IDTechEx's analysts were also bullish on the size of the market for thermoelectric systems that can convert unwanted heat energy to electricity. While thermoelectric systems have been around for decades, new solid-state thermoelectric devices can work with smaller temperature differences, increasing the number of places they can be used. At the show, the analysts forecast that the thermoelectric-generation market will more than double from 2014 to 2016, reaching nearly $95 million.

Automotive applications are an obvious target, but industrial applications are more likely to drive growth in this segment. Wireless sensors powered by excess heat in manufacturing settings can lower installation and maintenance costs by eliminating power and communications wires for each location.

Perhaps the most magical method of energy harvesting is drawing on ambient electromagnetic emissions. This isn't a new idea: Crystal radios were pretty popular once upon a time, and RFID tags and photovoltaic cells are pretty popular today. The concept can be taken further, however. It is possible to pull energy from the various radio frequencies that wash over us all the time. The Spanish textile research association Aitex, (http://aitex.es/en/) in collaboration with other researchers, has created cloth that contains tiny antennas woven directly into the fabric. This technology could be developed so that our clothing could capture enough energy to power biometric sensors and other wearable devices.

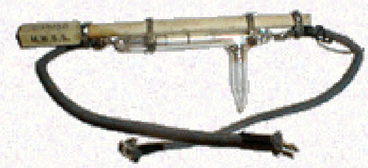
The IDTechEx conference was an excellent example of how the whole can be greater than the sum of its parts. There was an energy and enthusiasm among the participants that's been missing at many technology events in recent years. The excitement generated by the multiple markets, all experiencing rapid growth, was reminiscent of the heady early days of the personal computer, when anything was possible and amazing products were within reach. Energy harvesting is going to play an important role in changing the way we interact with everyday items, our data, one another, and even our own bodies.

This article originally appeared in print as "Reaping the Energy Harvest."



Marconi Coherer

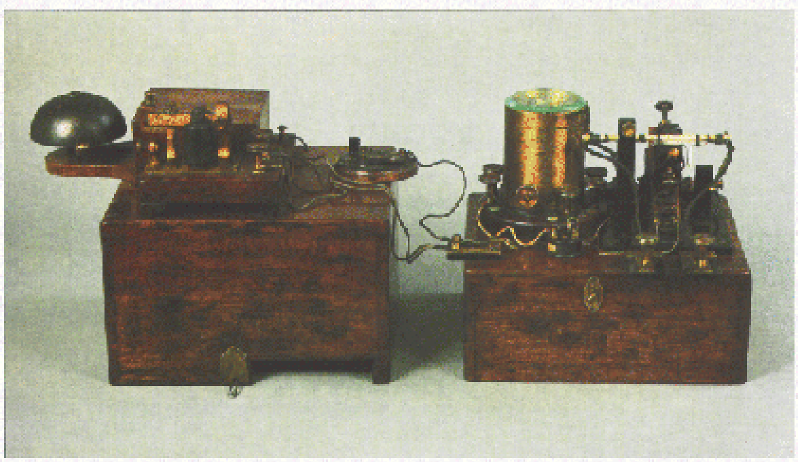
1895 - 1905



The coherer was the first device used to detect radio frequency signals in wireless telegraphy. Its operation is based upon the large resistance offered to the passage of electric current by loose metal filings, which decreases under the influence of radio frequency alternating current.

If you look closely you will see 2 metal electrodes separated by a small gap. Within the tube metal filings surrounded the electrodes. In the presence of radio frequency energy the filings cling together - cohere - and allow a current to pass. This current was used to actuate a telegraph sounder. The problem of the filings continuing to cling together after the removal of the RF energy was solved by tapping the coherer with a small mallet attached to the sounder after the arrival of each signal.

Below is a picture of Marconi's 1895 Coherer receiver (which, unfortunately, I do not own!) Look closely at the upper right corner of the photograph and you will see a coherer identical to the piece in my collection.



Marconi's wireless receiver, built in 1895.

Source: The Guglielmo Marconi Foundation: Historical Museum

The W8EXI Wingfoot VFO Exciter
High Technology In The 1950's
by Greg Latta, AA8V

Main Page - Introduction and Front and Side View Photos

Wingfoot VFO Exciter Pages:

Introduction:

The W8EXI Wingfoot VFO Exciter (transmitter) was built and designed by Jim Trutko, W8EXI (now, sadly, a silent key), in the middle to late 1950's with the assistance of the Goodyear Aerospace machine shop in Akron, Ohio. It is a very rare example of a homebuilt ("homebrew" in the lingo of amateur radio operators), state of the art, 1950's high frequency transmitter of the frequency multiplying type. It is the only one in existence. It was restored and redesigned in 1999-2000 by Greg Latta, AA8V.

In these pages are pictures of the transmitter and its various parts, circuit diagrams,

circuit descriptions, and a history of the restoration and redesign.

After restoring the Wingfoot VFO transmitter, I designed amd built a matching Wingfoot 813 Amplifier featuring an 813 beam power tube in grounded grid. The two units together make a wonderful combination with a conservative output of 250 watts.

The author (left) and Jim Trutko (right) at a presentation on the Wingfoot VFO Exciter for the Cuyahoga Falls Amateur Radio Club. All of the components of the restored exciter are visible on the table. From left to right the components are: meter panel, power supply, grid box, main chassis, remote control.

This page is dedicated to Jim Trutko, W8EXI, who was a shining example of what every amateur radio operator should be. We miss you Jim!

Front and Side Views of the Wingfoot VFO Exciter:

Exciter Grid Box: This is the "Grid Box", where the signal starts. This chassis contains the LC circuit (i.e. the coil and variable capacitor) for the Clapp variable frequency oscillator. It contains no tubes or transistors. Besides the coil and the variable capacitor it also contains twenty air trimmer capacitors and a band switch so that the bandspread can be adjusted over ten different ranges, originally the CW and phone segments of the 80, 40, 20, 15, and 10 meter amateur bands. It connects to the main chassis (which contains the 6AG7 oscillator tube) through a pair of coaxial cables. The chassis itself is built out of 3/8 inch aluminum, which makes it very, very strong and very rigid. With constant room temperature drift is as small as or less than that of modern rigs.	 Click on the image for a larger view. ***Click here for a super detailed view.***
Exciter Front Panel: The front panel of the exciter contains four controls. At the upper left is the plate tuning control, which uses a five to one planetary reduction drive. The plate loading	

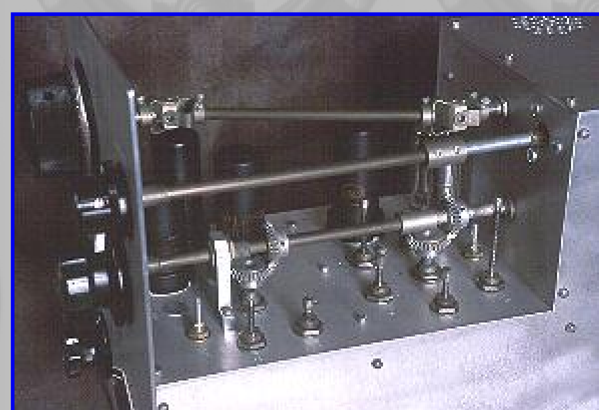
control is at the upper right, and the band switch is below the plate tuning and load controls. The band switch is a six position switch, which allowed for the addition of the 30m band during the restoration. The final screen control, which controls the power output, is at the lower left. The diamond shaped plaque on the front which says "W8EXI Wingfoot VFO" is the same shape as the "Winged Foot" logo that the Goodyear Tire and Rubber Company used in the 1950's. The embossing of the control functions on the front panel was done as part of the restoration.

Click on the image for a larger view.
Click here for a super detailed view.

Exciter Left Side View:
In this view of the exciter from the left side the cover is on the final amplifier compartment, as it normally would be during operation. The two voltage regulator tubes can be seen at the left. The lone metal tube just to the right of them is the 6AG7 2nd buffer/multiplier. The 6AG7 1st buffer/multiplier, 6AG7 Clapp oscillator, and 6J5 cathode follower tubes are clustered in a triangle just behind the front panel. Note the pair of universal joints used to connect the plate tuning control on the front panel to the shaft of the plate tuning capacitor at the rear. The plate tuning control is a National planetary drive with a five to one reduction ratio. This makes plate tuning very easy.

Click on the image for a larger view.
Click here for a super detailed view.

Exciter Right Side View:
The mechanics of the Wingfoot Exciter are quite involved. The plate tuning control (at the top of the front panel, towards the back of the photo) features a National planetary reduction drive on the front panel, which then connects to the plate tuning capacitor at the rear through a pair of universal joints and a long shaft. The plate loading control (at the top of the front panel, towards the front of the photo) connects to the loading capacitor at the back via a long shaft and a 1/4" straight coupling. The band switch in the middle of the front panel controls three separate switches. The 1st buffer/multiplier and driver stage switches are operated through right angle couplings mounted on the band switch shaft. The final amplifier bandswitch is connected directly to the shaft at the rear.



Click on the image for a larger view.
Click here for a super detailed view.

Exciter Top View:
This is the main chassis of the exciter as viewed from above. In the triangle of tubes on the left, the 6AG7 Clapp oscillator tube is at the top, the 6J5 cathode follower is on the left, and the 6AG7 first buffer/multiplier is on the right. To the right of the triangle is the 6AG7 2nd buffer/multiplier tube and a pair of voltage regulator tubes are just to the left of the final amplifier compartment. Inside the final amplifier

compartment is the 2E26 final amplifier tube on the left and a pair of 5814 (12AU7) tubes on the right. One 5814 is used for the differential keying and the other is used to control the screen grid of the 2E26 final amplifier. Note the use of 1/4 inch aluminum for the bulkheads.

Click on the image for a larger view.
Click here for a super detailed view.

Exciter Top View - Final Amplifier Compartment: This is a close up view of the final amplifier compartment. (The compartment is normally covered, but the cover has been removed to show the interior.) The 2E26 final amplifier tube is at the upper left of the compartment, and the 5814 (12AU7) differential keying and final amplifier screen control tubes are at the upper right. The plate tuning capacitor is on the left half way up with a universal joint on its shaft that connects it, via an aluminum shaft, to the front panel. The plate loading capacitor is the double section capacitor at the lower left The bandswitch is visible under the plate tank coil.

Click on the image for a larger view.
Click here for a super detailed view.

Exciter Remote Control And Meter Panel: This picture shows the remote control unit for the exciter and the meter panel. The remote control on the left offers three modes: Operate, Standby, and Spot. In Operate, all stages are active. In Standby, only filament voltages are activated, and the exciter plate supply is disabled, which keeps heating in the power supply to a minimum. In Spot mode, the final amplifier is disabled, but all other stages are active, which allows the operator to hear the exciter signal in the station receiver.

The meter panel simultaneously shows the final amplifier grid, screen, and plate currents on Weston type 301 milliammeters. Weston type 301 meters were among the best. Back in 1967, a single meter cost $14.40 from Allied Electronics, equivalent to about $85 today.

Note the shielded wire used to connect the meter panel to the exciter.

Click on the image for a larger view.
Click here for a super detailed view.

Click here for pictures and information on the matching Wingfoot 813 Amplifier

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Back to Dr. Greg Latta's Electrical Engineering and Amateur Radio Pages

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Questions, Comments, and E-Mail

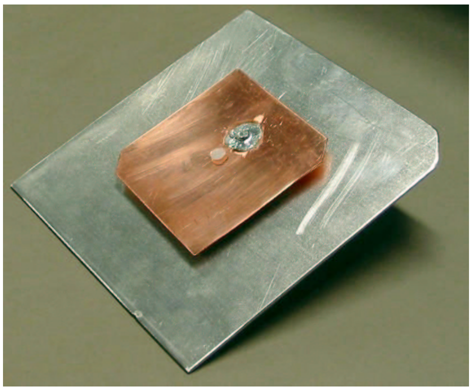
If you have any questions or comments, you can send E-Mail to Dr. Greg Latta at glatta@frostburg.edu

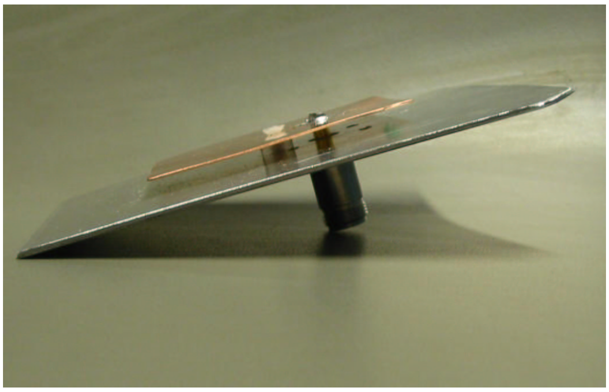
Thanks for stopping by!

PATCH ANTENNA FOR A GPS RECEIVER

Pekka T. Pussinen, OH8HBG
Marko Autti, OH9LMP/OH9CW

This antenna design is RHCP truncated patch antenna for 1575 MHz (GPS). Gain of the antenna is approzimately 7 dBi (> 4 dBd) and the 3 dB beam width is approzimately 60 degrees. The axial ratio of the antenna is typically better than 1,5 dB.





The antenna construction and theory is explained in Finnish article only. The English version is provided as informational supplement only.

The material is 2 mm thick aluminium sheet as a reflector and 1 mm thick copper plate as a radiator. Size of the reflector could be larger as specified. Connector was Suhner N-female connector, but any other type of connector could be used (adjust drilling positions and sizes).

All units in the drawings are in millimeters.

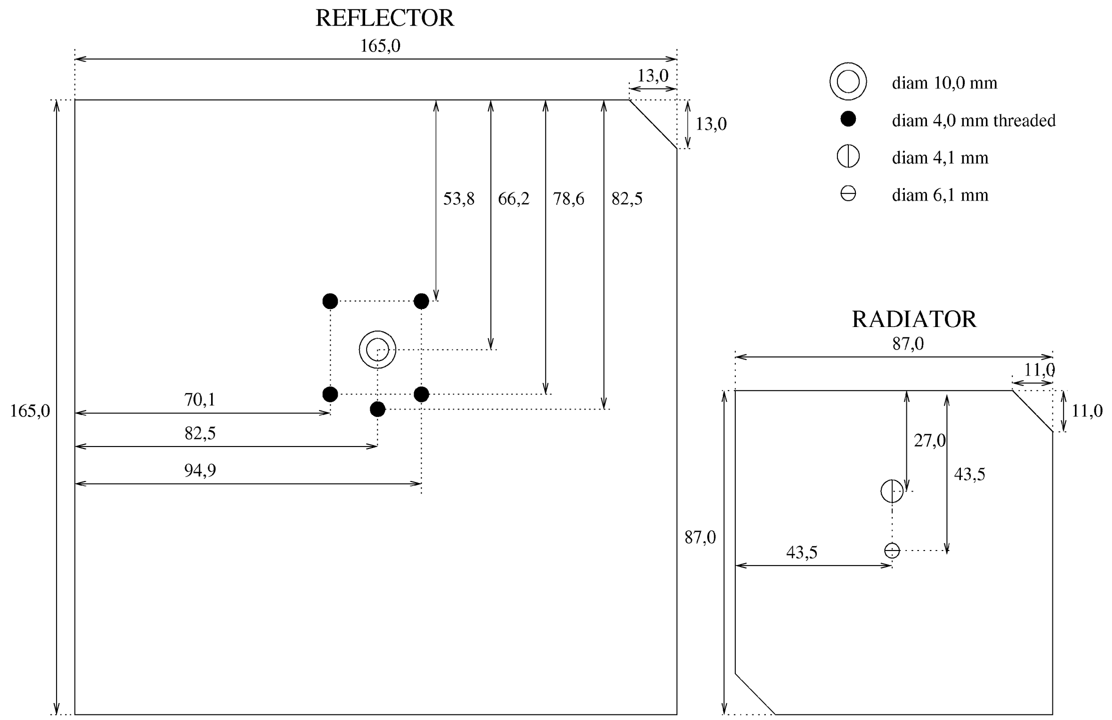


Illustration 1. Element drawings in millimeters.

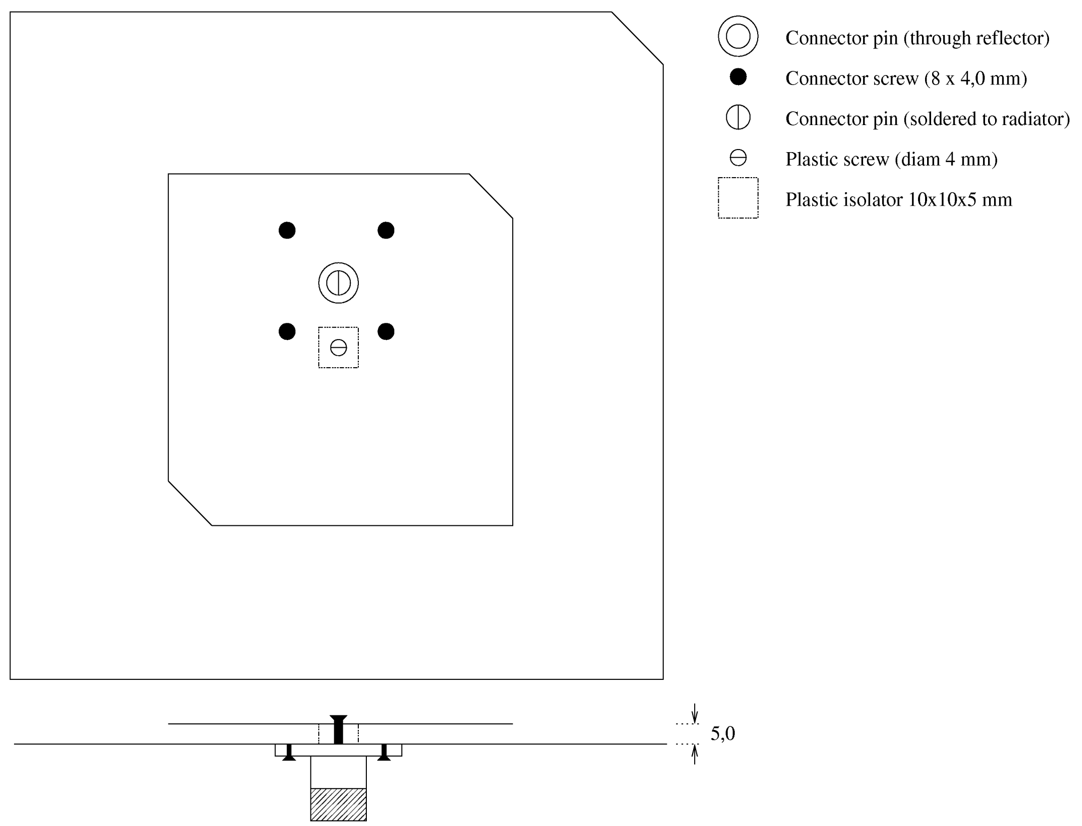


Illustration 2. Build up of the antenna, all units in mm.

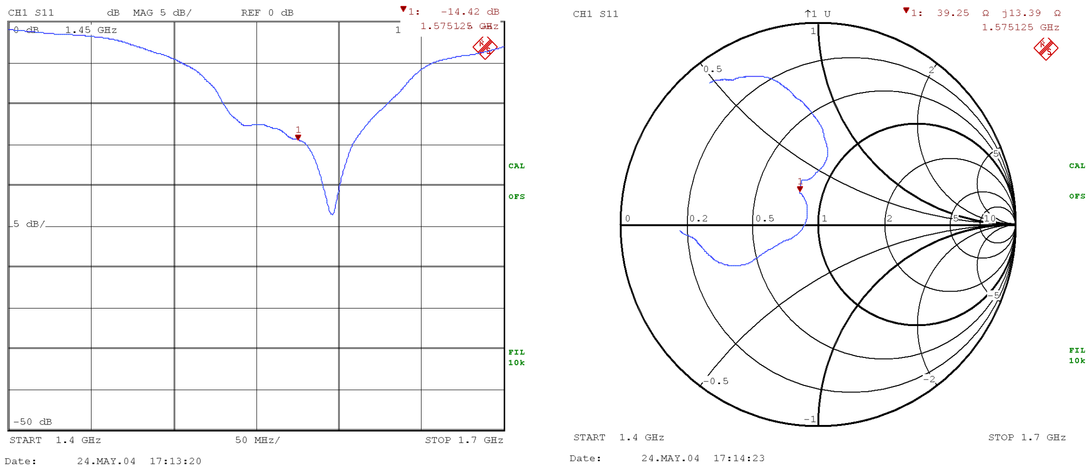


Illustration 3. S11-plot of the antenna.

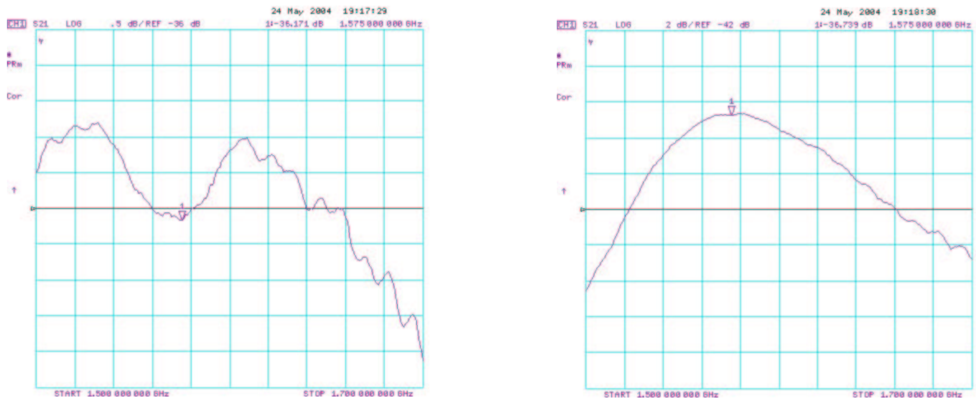


Illustration 4. Vertical (left) and horizontanl (right) plots of the radiating antenna.
NOTE: 0 dBi reference line is -44 dB.

- Home
- Blog
- Projects
- Contact
- Links
- Guestbook

Baluns

June 20th, 2009 by g4lds

This is a recent project that I have carried out. A simple balun

A balun using ferrite ring

A balun using ferrite rod

Baluns - you either swear at them or swear by them!

So what do they do? They simply allow a balanced item like a centre fed dipole to be fed with an unbalanced system like coax (or balanced feeder (open wire balanced) to an unbalanced ATU) to try to reduce RF currents causing EMC or tuning problems. Now the next step is which one to use, a voltage or current balun?. Now I have only built and used a simple current balun so these thoughts are based on my experience.
Back in time before I held a license and was still a SWL, I built a trap dipole and needed a 1:1 balun at the feed point, saw a kit for a balun and sent off for it. Having got the kit and instructions my next problem was trying to understand what was meant by trifilar windings. I thus learnt it means three parallel windings (and of course bifilar is two windings!). Having understood this, I made it and it seemed to work. Later on I started to read up more on baluns and trifilar and bifilar windings. A look in Les Moxon's book on aerials explained more and thus

made me realize how simple baluns are to make. A 4:1 balun is even simpler to make than a 1:1 balun due to having one less winding to make!

Making a simple current balun

I feel that anything you make you learn a lot from both the practical and theory so here's some tips to help you make 1:1 and 4:1 current type Baluns that will save you some cash! You need a ferrite rod or core, a smallish box, suitable connectors some wire (either hard drawn copper or heavy duty PVC covered different colour wires) fixings and your soldering iron, cutters etc.

Now to get the ferrite rod. You may have a defective MW portable radio, which a great source for the ferrite rod for a balun if not then a ferrite ring can be used.

My Method

The wire I have used is 18 SWG enameled wire.
Straighten the wire (tie one end around a door handle, pull gently until straight if you don't have a vice) to remove any kinks etc and cut three lengths around 18' long.
Lay the three straight wires in a triangular bundle with no twists and wrap in PTFE tape (as used by plumbers and stocked by most DIY stores) firmly but not too tight. (Helps to keep the wires straight and in one line! Wind 12 – 18 turns of the bundle onto the ferrite former (rod/ring) leaving NO GAPS between turns (wind slowly and carefully to ensure this). The method I used was to find the middle of the bundle and wind onto the former from this point towards the two ends. I then use a tie-wrap to hold the two ends in position on the former. If using a rod, ensure that the bundle usually lays flat on the rod but if not gently squeeze in the vice jaws taking care not to break the rod or scratch the enamel). Now define which end of the windings are your start and which is your finish. Scrape off the enamel on the end of the separate wires, buzz through to identify the individual windings (A, B & C) and connect up as per circuit diagram. (I show the connections for both 1:1 and 4:1 and using a switch you could make a 1:1 and 4:1 balun in one unit) If you are making a 1:1 balun connect a 50 Ohm dummy load to the balanced side (or output side) and aerial analyzer to the unbalanced (or input side) via a short coax lead. (If you're using a low power transmitter ensure the 50 Ohm load can handle the power, 4 x 220W 1w resistors in parallel should be ok) to check the VSWR. (Likewise if you built a 4:1 balun, put a 200 Ohm load on the output or balanced side). If the measured VSWR is high i.e. greater than 2:1 check your wiring!

I used a simple ABS box to mount the transformer with a SO259 connector on the input and bolts on the output for the aerial feeder or elements.. The transformer can be glued in the bottom of the box for mechanical strength.

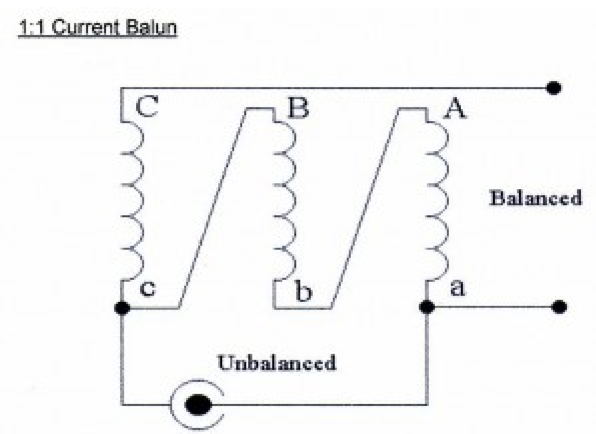
I have used both ferrite rings and ferrite rods. The pictures, I hope explain more. I also attach a Excel plot of one balun I made, fairly flat upto around 33 MHz!

And to prove it here is a picture of it being measured on 29Mhz.

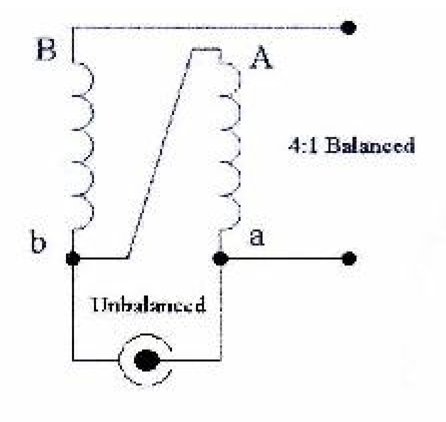
Info on types of cores

Core type	Number of turns	Power
T-80-2	25	60 watt
T-106-2	16	100 watts
T-130-2	18	150 watts
T-157-2	16	250 watts
T-200-2	17	400 watts
T-200A-2	13	400 watts
T400-2	14	1000 watts

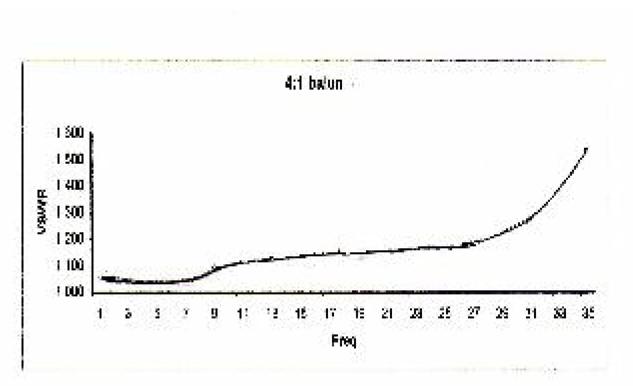
Cct diags



1:1 Balun



4:1 Balun



Plotted response curve

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RIDING ON A WAVE
The Technical Stuff

WHAT HAVE RADIO WAVES EVER DONE FOR US?

Well radio waves have *carried* Terry Wogan, Tony Blackburn, Chris Tarrant and Coronation Street to us - riding on the wave, that's what!

THE BASICS

Radio waves are part of the *Electromagnetic Spectrum.* All waves of the electromagnetic spectrum travel at the same speed of 300,000 kms per second in space. Note that sound waves are NOT part of the electromagnetic spectrum.

The electromagnetic spectrum stretches from radio waves at the lowest frequencies (longest wavelengths) at one end (the relatively harmless end) through Infra Red (heat) waves, visible light waves all the way up to Gamma Rays at the very shortest wavelengths (highest frequencies) - the harmful end of the spectrum. Gamma rays are harmful to human tissue and are produced by events including the detonation of atomic bombs and from celestial objects such as quasars.

THE ELECTROMAGNETIC SPECTRUM:

	Radio	Sub-Millimeter	Infra-Red	Visible-Light	Ultra-Violet	X-rays	Gamma-Rays	
Longest Waves / Lowest Frequency								Shortest Waves / Highest Frequency
Typical Wavelengths	1000km	100µm	10µm	7.8µm - 3.9µm	100nm-10nm	100pm	1pm	
Notes:	3Hz - 30GHz	1 THz - 10 THz	100 THz	Red to Blue			(harmful to human tissue)	

A Representation of the Whole of the Electromagnetic Spectrum

We will concentrate on the relatively harmless end of the electromagnetic spectrum - Radio Waves - which include Radio, Television and mobile phones.

THE RADIO PORTION OF THE ELECTROMAGNETIC SPECTRUM:

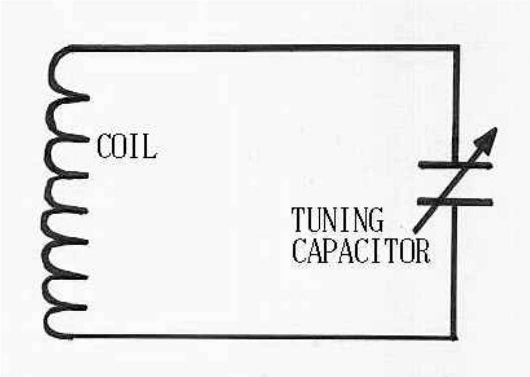
Classification:	ELF	VLF Very Low Frequency	LF Low Frequency	MF Medium Frequency	HF High Frequency	VHF Very High Frequency	UHF Ultra High Frequency	SHF - EHF	
Longest Waves									Shortest Waves
Description:	Extremely Long Waves	Very Long Waves	Long Waves	Medium Waves	Short Waves	Very High Frequencies	Ultra High Frequencies	Super to Extremely High Frequencies	
Frequency ranges:	3Hz-300kHz-3kHz	3kHz - 30kHz	30kHz to 300kHz	300kHz - 3.0 MHz	3.0MHz - 30MHz	30MHz - 300 MHz	300MHz - 3.0GHz	3.0GHz - 30GHz	
Examples of types of use:		Marine & Military	LW Radio, Amateur Radio	MW Radio, Amateur Radio	Military, SW Broadcasts, Amateur Radio	FM Radio, DAB Radio, Amateur Radio	TV, Mobile Phones, Amateur Radio	Satellite Transmissions, Amateur Radio	

A Representation of the **RADIO** portion The Electromagnetic Spectrum

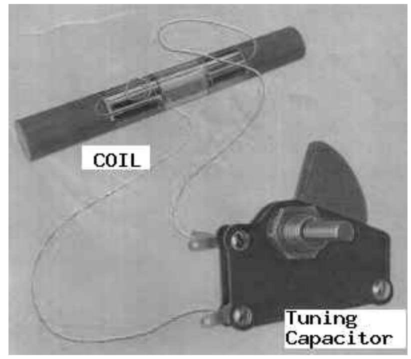
TUNING IN !

The receiving device has to tune into the required transmission and be able to reject all other transmitters within range. This is done with a *Tuned Circuit*. The tuned circuit acts as a Filter, without one all available broadcasts would be received, which would be very confusing to the listener and quite useless. The tuned circuit filters out the transmissions that are not required.

If we look at the humble crystal set it has a very simple tuned circuit consisting of a coil and a variable capacitor. The size of the coil and the number of windings of wire on it and the value of the variable capacitor determine which part of the radio spectrum is received. The variable tuning capacitor provides a convenient means of tuning to the required station. The illustration below shows the circuit diagram and the typical components used. Once the tuned circuit has selected the frequency of the required radio station it is passed on to the detector or diode that will provide audio to the headphones.



Circuit diagram of a tuned circuit



Physical layout of a tuned circuit

MODULATION and DETECTION

In the case of AM radio the radio station firstly produces a radio frequency *carrier* (the radio wave) that is of constant average amplitude, this radio wave is *modulated* with, and then carries, the audio frequencies of voice and music etc from the radio studio. The modulation varies the amplitude of the carrier in response to the frequency of the music or voices being transmitted - the sounds (audio) is effectively superimposed onto the transmitted radio wave. This is Amplitude Modulation (AM).

Once the tuned circuit has tuned into the required radio station, if the signal was fed straight to the earphone nothing would be heard since the earphone could not respond the very fast alternations of the radio wave. Radio waves can alternate at frequencies of between approximately 100,000 Hz and 100,000,000,000 Hz, whereas the sound frequencies that we can hear and that an earphone or loudspeaker can reproduce generally lie between 20Hz and 20,000Hz - quite a different frequency range!

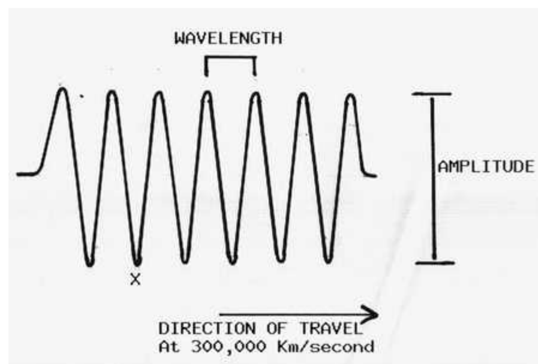
The earphones have to reproduce the *audio frequencies* that have been modulated onto the carrier wave at the transmitter. These audio frequencies are recovered by the electronic circuits of the listener's radio receiver by using a 'detecto'r, often a *Diode.* The diode in the crystal set acts as a rectifier, removing alternate half cycles of the radio carrier, so that the resulting half waves will be in the same direction and the resulting detected audio frequencies cause the diaphragm of the earphone or the cone of a loudspeaker to move in accordance to the average strength of the carrier.

The radio wave shown in the diagram on the right is travelling from left to right at as constant and unvarying speed of 300,000 kms (in space). The pattern of a wave is a constant and repeating cycle.

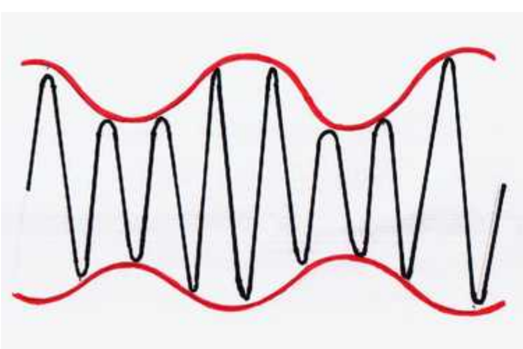
The wavelength of the radio wave is measured as the distance between two peaks of the wave. The frequency of a radio wave is measured as the number of peaks that pass by a specific point (e.g. point X) every second and is expressed in Hertz (Hz) after Heinrich Hertz.

Since the speed of a radio wave is always the same varying the wavelength must also vary the frequency. If the wavelength is increased the number of peaks that can pass point X must be lower so the frequency of the radio wave will be lower. Conversely if the wavelength is reduced the number of waves that can pass the single point must increase causing a higher frequency. The calculation to convert a frequency to a wavelength is:
300,000,000 ÷ frequency (Hz) = wavelength(m)
or
300,000 ÷ frequency (kHz) = wavelength(m)
or
300 ÷ frequency (MHz) = wavelength(m)

The other consideration of a radio wave is the amount of energy that it is carrying, this is the Amplitude, and is the height of the wave, as seen in the diagram opposite.



Representation of an unmodulated radio (carrier) wave



A Modulated Carrier Wave

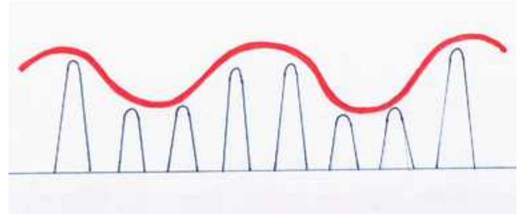
Modulation:

At the transmitter the audio from the radio studio is *modulated* ('superimposed') onto the carrier wave. In the case of an AM radio transmitter the frequency, and therefore the wavelength, remains constant.

The modulation of the sound alters the *amplitude* of the radio wave, varying the amount of energy that the wave carries. The audio signals that we want to hear are carried on the radio wave ready to be detected by the listener's crystal set diode or detector on their transistor radio.

The radio carrier wave is represented by the black line in the diagram on the left, while the audio that is carried on it is represented by the red line - the varying amplitude of the carrier wave.

The carrier wave of your favourite AM radio station, perhaps 'Classic Old', is passed through the detector or diode and the resulting audio, represented by the red line, is removed from the carrier and passed to the earphones which convert the electrical signal to sound waves that can then be heard. Magic!



The detected audio wave

SOUND WAVES ARE DIFFERENT TO RADIO WAVES

Bear in mind that sound itself is not transferred to our ears (or to a microphone) by waves in the electromagnetic spectrum. Sound waves are transferred by vibrations in a physical matter such as (normally) air molecules or other substance perhaps through the vibrations of the molecules in wood, metal or plastics etc

A high pitched sound has a higher frequency, and therefore shorter wavelength, than a lower pitched sound which has a lower frequency and therefore longer wavelength.

Sound waves cannot travel through space. Space is effectively a vacuum and thus has no physical matter with which to transfer molecular vibrations. The only way we can hear sound through space is if they are first modulated into a radio signal (by a microphone and radio transmitter (in an environment that has an atmosphere that can convey the sound to the microphone!)), - the radio signal is transmitted across space and then received on a radio receiver which then de-modulates the radio carrier wave so that sound can be heard from the loudspeaker.

Physical sound waves that can be heard by the human ear are typically at frequencies in the region of 20 hertz to 20,000 hertz (cycles per second). The radio portion of the electromagnetic spectrum (which is quite different to the sound spectrum) ranges from about 3 hertz to about 300,000,000,000 hertz (cycles per second); the whole of the electromagnetic spectrum itself is vastly wider than this, of course. Any SOUND wave can be piggy-backed onto a radio wave by means of modulation (e.g. Amplitude Modulation (AM), Frequency Modulation (FM) or Single Side Band (SSB) for example) by using a radio transmitter.

^top of page

A READER'S QUESTION!

I have just spent the last three hours reading and re reading your website on radio, it is a fantastic documentation and thank you for taking the time to put together such an informative read.

My reason for emailing you is quite simple I am currently writing an essay on radio, including both technological and sociological issues both past and present. I have read your site several times and the main thing that confuses me is information on broadcasting frequencies/distances and formats.

I don't understand how they all relate to each other, for example 'Radio Four lost 206m (1457kHz) and 261m (1151 kHz) 'how do they relate? is the 'meterage', the distance they can transmit or the wavelength or is this the same thing, or is 206M the distance and 1457kHz the wave length, if so how are these related. Also I presumed LW could be transmitted further, but its seemed a lot of 'National BBC' programmes were transmitted on MW, how is this possible. Also how does the power of a transmitter/radio mast come into the equation, does it transmit to smaller masts which amplify the signal to get the coverage on MW and is the higher the power the further it can transmit. You also commented on early stereo transmission how was it possible as both local and national masts where used for each channel how can you tune to two stations at once. How does FM come in all this as this seems to be the standard and highest quality radio achievable now as early BBC broadcasts did not use this method.

Thank you for your time, I do hope you can help me out on these questions, maybe I'm being stupid and the answers are just staring me in the face.
Kind Regards
Lee Slater

I will do my best to answer, Lee:

FREQUENCIES and WAVELENGTHS

A radio station is transmitted on a specific frequency within a given defined 'wave-band'. For the general ANALOGUE broadcasting that we a talking about here, there are three domestic wavebands: 1/ Long Wave 2/ Medium Wave 3/ VHF.

In Europe the authorities (co-ordinated by the the International Telecommunications Union [ITU]) have allocated the domestic broadcast radio stations space within the limited radio frequencies portion of the electromagnetic spectrum as follows:

Long Wave - occupies the part of the electromagnetic spectrum stretching from a frequency of 148.5 Kilohertz to 283.5 kilohertz (kHz)
[Note: 1 kilohertz is one thousand cycles of a radio wave per second - referred to as kilocycles per second from the 1920s to the 1970s when the term kilohertz was more widely adopted. kilocycles per second is abbreviated to kc/s : Remember that a radio wave is an alternating electrical current constantly cycling from positive to negative and back again, and so on. An oscillation is simply the time it takes for the voltage of the transmitter to go from + ve to - ve and back again and is expressed as the frequency.] [Martin Watkins adds:- A transmitter is really just a battery being whirled round and round between its terminals very fast!), and that this can (and was) in the early days achieved by speeded up generators]

Medium Wave - occupies the part of the electromagnetic spectrum stretching from a frequency of 526.5 kilohertz (kHz) to 1606.5 kilohertz

VHF (Very High Frequency) (Band II) Broadcast Band stretching from 87.5 megahertz (MHz) to 108.0 MHz
[Note: 1 Megahertz is one million cycles of a radio wave per second, previously referred to as megacycles per second. abbr. mc/s]

DAB in the UK (Digital Audio Broadcasting - or plain simple 'Digital Radio') - A small part of radio spectrum stretching from around 209 MHz to 216 MHz. Digital radio stations are broadcast is blocks or 'ensembles' called "Multiplexes". Each single multiplex carries not just one radio station, but a number of different stations depending on the level of digital compression used. The higher the compression (i.e lower bit-rates) the lower the quality of the audio will be, but the larger the number of stations that can be accommodated into the multiplex. Many areas in the UK can receive DAB radio and can typically obtain three multiplexes: BBC National (all the BBC's radio national stations - including Radio One, Two, Three, Four, FiveLive, 6-Music, BBC 7, 1-Xtra etc), Commercial national Digital One (Classic, Virgin, Talk Sport, OneWord, PrimeTime etc etc), Local (BBC Local Radio and various commercial local stations). Some areas, especially around London, can receive more local

multiplexes or a regional multiplex, whereas other areas receive fewer multiplexes (e.g. Northern Ireland due to lack of frequencies available). **MORE**

TELEVISION in the UK - Currently both analogue 625 line colour broadcasts and digital terrestrial television (DTT), in the form of "Freeview" and "Top-Up-TV", use frequencies in the UHF (Ultra High Frequency) part of the radio spectrum between 470MHz and 860MHz (known as **Band IV** and **Band V**). In other parts of Europe and the world, **Band I** (approx 46 MHz to 67 MHz) and **Band III** (approx 175 to 210 MHz) are still used for television broadcasting.

Beyond The Broadcast Bands

Outside of these defined 'broadcast bands', the frequencies in between are used for all manner of other communications - e.g. police, fire, ambulance, boating and shipping, private 2 way radio, amateur radio etc. etc. etc.

The methods of conveying the sound produced by the radio station vary according to the band in question:

For the **Medium Wave** and **Long Wave** bands, it was decided from the outset of radio broadcasting in the 1920s that the method of ***modulating*** the radio wave would be **AMPLITUDE MODULATION** (**AM**).

When the **VHF band II** was released for broadcasting in the 1950's AMPLITUDE MODULATION was experimented with, but it was eventually decided to use **FREQUENCY MODULATION** (**FM**) as FM was found to be somewhat less susceptible to some forms of interference - too complex to go into here.

So you see 'FM' is not a '*band*' and neither can 'AM' be described as a *'band*' - they are just methods of conveying the radio station output. FM *could* be used to broadcast on Medium Wave or Long Wave (not that anyone would be able to hear it on an existing Medium Wave AM radio!) just as AM could have been used to broadcast on the VHF broadcast band.

Now we come to the WAVELENGTH question -

A radio wave is an oscillating wave in the radio frequency portion of the electromagnetic spectrum. The electromagnetic spectrum stretches from the lowest frequencies at the 'radio' end of the spectrum through the higher frequencies of 'sub-millimeter' ; 'Infra Red' (i.e. Heat!); Visible Light; Ultra Violet; X-Rays (as used in hospitals) and harmful 'Gamma Rays' (as emitted by fissile material and atomic bombs)

All these waves have one thing in common, they all travel at 300,000 kilometers per second (in free space) - commonly called **the speed of light**.

As all electromagnetic waves oscillate at a certain frequency to form a wave of a certain length, the Wavelength and the Frequency relationship is inextricable linked. Since the speed at which the wave travels is fixed, at 300,000 km per second, if the *frequency* of the wave is varied the only other variable that can change is the *wavelength. (Refer to Mr A Einstein for more detail)*

The mathematical relationship between wavelength and frequency is expressed in this fundamental and very important formula:

Wavelength (in meters) = 300,000 / Frequency (in kHz)

and also to put it another way:

Frequency (in kHz) = 300,000 / Wavelength (in meters)

SO: As the frequency of the wave is *increased* the wave length *decreases* .

If we look again at the broadcast bands we can see the relationship between frequency and wavelength:

Long Wave: 148.5 kHz to 283.5 kHz or expressed in wavelengths as 2020 meters to 1058 meters.

Medium Wave: Frequencies from 526.5 kHz to 1606.5 kHz or expressed in wavelengths as 570 meters to 187 meters.

Wavelengths in Meters were always quoted by radio stations and marked on radio dials until the 1980s when frequencies were more generally adopted as the method of expressing where the particular station appeared on the radio dial.

VHF radio has always used mc/s or MHz to express the position on the dial, but just for clarification here are the meter values too!

VHF: Frequencies from 87.5 MHz to 108.0 MHz could be expressed as 3.428 meters to 2.778 meters (but in reality the expression of meters is never used on air).

Now look at a practical example:

Many years ago Radio Four lost the use of 1457 kHz frequency. But when that happened radios were marked in Meters, so what was the wavelength of that transmission?

Take **300,000** and divide it by **1457** and you will get an answer of **205.90** Meters. This is rounded up for simplicity when being quoted on the air by presenters as **206m** . Simple!

DISTANCE TRAVELLED

The fact that a radio station, such as BBC Radio Four from the 198 kHz Droitwich transmitter has such a very long wavelength means that for each cycle of oscillation of the radio wave it must travel 1515 Meters.

Compare that to Capital Gold Radio on 1548 kHz medium wave this has a much shorter wavelength, and the wave only travels 194 meters per cycle.

Very simply put, for a given and equal transmitter power, for each cycle of the radio wave the BBC Radio Four 1515 m transmission covers a much bigger area than the shorter wavelengths used by Capital Gold Radio on 194 m. Shorter wavelengths are absorbed and attenuated (reduced in intensity) more quickly and therefore cannot cover such a large area for a given transmitter power.

This effect explains why BBC Radio Four only requires 3 main long wave transmitters on 198 kHz to cover virtually the whole of the UK, while BBC Radio Five Live needs 10 main medium wave transmitters to obtain near national coverage.* The longer waves of BBC Radio Four at 1515 meters are absorbed and attenuated to a much lesser degree than those of BBC Radio Five Live using medium wavelengths, which are absorbed to a greater degree which causes the signal to fall off more rapidly with distance from the transmitter.

[Martin Watkins adds: It's not an exact analogy, but the bass drum of a brass band playing in the distance will be heard more clearly than the piccolos or fluegel horn. As I say it's not an exact analogy with LW/MW attenuation, but HF sounds are screened by obstacles more than LF, explained at least in part by their wavelength, and by absorption in the atmosphere.]

[* BBC Radio Four also uses 9 filler transmitters on medium wave, while BBC Radio Five Live also uses an additional 13 medium wave filler transmitters]

TRANSMITTER POWER

Certainly the relationship between power and distance is important. The more energy that is put into the radio wave the further away it will provide an effective an listenable signal. This in exactly the same way as using a higher power light bulb will be more more effective and be seen further away compared to a lower wattage bulb. (Of course light is part of the electromagnetic spectrum to which radio waves belong). A 150 Watt light bulb will, for example, be much brighter and therefore be seen further away than a 25 Watt bulb.

It is also interesting to note that doubling the transmitter power does not double the distance that the transmitter will cover. To double the signal strength at the listener's radio receiver aerial a power increase of 4 would be needed!

AERIALS

For a radio aerial (either transmitting or receiving) to have maximum effect it must be of a resonant length compared to the radio frequency that it is transmitting (or receiving, of course). For a long wave station a very tall aerial is required to be able to resonate effectively at those wavelengths. Long Wave = long wavelength = long or tall aerial.

For medium wave the wavelengths are obviously shorter than long wave so a shorter aerial is required.

Many medium and long wave stations simply use a tall metal mast as the aerial, the height of which will vary depending upon the wavelength of the service being transmitted, but will be many tens of meters in height.

For VHF (or if you must call it FM) broadcasting the aerials are going to be much smaller, only a few meters across, and these will be attached to the top a tall masts or towers to gain height advantage.

STEREO

In the early days the BBC experimented with Stereo broadcasts. Stereo requires **two** AUDIO channels; (simply put) one to carry the sounds from the right hand microphone channel and the other transmitter to carry the sounds from the left hand microphone channel.

The only way to do this in the 1920's was to use two radio transmitters on separate frequencies. In this early stereophonic experiment the right hand audio channel was transmitted over the BBC long wave transmitter, which covered most of the country, while the left hand channel was simultaneously transmitted over the BBC's numerous local medium wave transmitters.

For listeners lucky enough to have two radios, they could tune one into long wave and place it on the right of the room while the other was tuned to medium wave and placed on the left hand side of the room. By sitting in between the two radios the listener could get a sense of the space and ambiance and stereo sound-stage that we all take for granted today!

In the 1960's stereophonic transmissions were introduced to the VHF (FM) radio services of the BBC. This time, however a new system had been developed, called the *Zenith GE Pilot Tone system* (developed by General Electric of America) that did not require a separate transmitter and radio for each audio channel. The new system used the existing VHF frequency of the BBC station and added (Coded) in the extra components in the form of a 'multiplex' on top of the existing radio signal. The idea was that the system would be compatible with existing mono radio sets, which would continue to receive the programmes unaffected and as normal in mono of course, but new radio receivers would be available that were fitted with the special ***Stereo Decoders*** required to extract the multiplexed stereo components and reproduce a stereo signal that would be fed to twin speakers via a stereo hi-fi amplifier. The Zenith GE Pilot Tone System is still used today on the VHF/FM band. Incidentally the Pilot Tone is an almost inaudible **audio** tone of 19kHz that is transmitted along with the sound of the radio station, when a suitably equipped radio tuner 'hears' this tone, it switches on the stereo decoder circuit so that the stereo programme can be resolved and heard.

(Incidentally, the 19kHz audio tone should then be stripped from the recovered audio by a special and very steep audio filter before it reaches the audio amplifier stage, however some poorly designed (read cheap) radio tuners do not do this effectively and people with very acute hearing can sometimes still hear the high pitched whistle!)

Hope this answers your question in some small way.

MORE QUESTIONS...

I'm a faculty member in the MIS department at Temple University (Philadelphia, Pa.). One of the courses I teach is the introduction to networking. You're page on radio info is great! I may direct some of my students to this page to get a better understanding of the various uses of each range of frequencies in the RF spectrum.

Here is one additional question for you. Do you know where I can find information regarding the RF spectrum that explains other things about the various bands such as the type of range you can expect from each band, the data rates you might expect, the things that cause the most interference, etc.?

Thanks,

Mart Doyle

Hi Mart,

Thank you for your-mail and your kind comments. I don't pretend to be a radio engineer, or particular expert, but I have presented the information on my website as useful material that I have previously researched and used in my own hobby of radio. I hoped that others would find this useful, as I have done, and I am glad that you have too,

As for your other questions, I don't immediately have a reference that may answer them. However I do have a number of friends 'in the know, so I will ask them for you.

In simple terms, for local ground wave contacts, the longer the wavelength (the lower the frequency) the further the signal will travel - for an antenna of given efficiency. In Europe we still use Long Waves (150 kHz to 300 kHz) for the transmission of AM radio stations. This means that during daylight in ground-wave conditions (night-time is different due to sky-wave reflections) long wave stations in France and Germany are quite audible here in the UK. Also the 198 kHz transmissions from the BBC are very popular across north west Europe.

This means that the whole of the UK can be covered with just three long wave transmitters using a single frequency (albeit that a few additional medium wave transmitters a required to fill in the 'mush zones' where the co-channel transmissions overlap and interact). Contrast this with the national medium wave (medium frequency, AM, 500kHz to1700 kHz) network that requires perhaps a couple of dozen transmitter to cover the UK and the or more, and the VHF (very high frequency 'FM', 88 MHz to 108 MHz) network that requires hundreds of transmitters to cover the UK (this is because VHF and UHF radio waves are very much line-of-sight. Medium wave and long wave signals tend to hug the earth more - following its curvature.)

If we have a look a high frequencies (HF, short waves) then these are locally quite short range, useful for short range local contacts like CB radio, so it may seem odd that short waves are so popular for international 'world band' broadcasting. However short waves are readily reflected off the ionosphere in the earth's upper atmosphere. In fact short wave can travel all the way around the earth by multiple bounces off the ionosphere and the earth's surface.

Medium wave radio waves are also subject to a similar effect during the hours of darkness when the ionosphere is able to reflect them, therefore allowing MW signals to travel a greater distance. VHF and UHF can also be reflected great distances but under a different and unpredictable effect known as "Sporadic E" - reflections off the E layer of the atmosphere.

A consideration for general domestic use is aerial efficiency. The longer the wavelength the longer the aerial required to work efficiently. As a rule of thumb a 1/4 wave aerial is a fair compromise for a reasonable efficient aerial system. This means that for a VHF (FM) transmitter using, say, 98 MHz a 1/4 wave ground-plane aerial would be about 0.76 meters long. That's quite easy to accommodate. If you decided to use, say, 1000 kilohertz medium wave, then your 1/4 wave monopole radiator would be 75 meters high. If you decided to use a long wave transmission on 200 kilohertz, then your 1/4 wave monopole radiator would be 375 meters high! (In practice professional broadcast transmission engineers use clever techniques such as loading a shorter aerial so that it appears electrically longer to the transmitter. One must also bear in mind that even though a VHF aerial, used for FM radio, is quite small, it must be mounted very high up so that it has a good 'view' of the horizon. So the masts used for both medium wave and VHF broadcasting might very end up being of very similar height anyway.)

Aerial efficiency can play an important part in local communications. Here in Europe we can use (as I do myself) Citizens Band (CB) Radio at 27 MHz (high frequency, short waves), or PMR 446 (446 MHz, UHF) walkie talkies for short range two way communications. A CB radio uses a 4 watt transmitter and a PMR 446 radio uses a 0.5 watt transmitter. Given an efficient matched aerial of correct length (about 3 meters long for CB and 16 centimeters long for PMR446) CB Radio can cover about 5 miles and PMR446 about 1 or 1.5 miles. However when using hand held walkie-talkies with a need to use small easy to handle aerials it may be found that PMR446 has as good, if not better range than a CB Radio. This is because the aerial on a PMR446 radio is very short anyway and thus easy to handle and will be the correct length for good efficiency. However an aerial on a CB radio would need to be a couple of meters long for proper efficiency - not conducive to easy handling (!) - so often a short "Rubber Duck" aerial might be used that is only a foot or so long. This reduces transmit and receive efficiency considerably, so much so that it may be that the 0.5 watt transmitter used by the PMR446 radio into an aerial of the correct length will be much more effective than a CB radio using 4 watts into an antenna of the incorrect length.

As for frequency, it is my understanding that the higher the frequency, i.e .increased cycles per second, the rate at which data packets can be transmitted can be increased. I imagine that this is why ultra high frequencies of 2400 and 5000 MHz are used for wireless routers and access points used in Wi-Fi networks.

I hope this is of interest.

I will try to come back to you with more as I have it.

Regards,

Mike

Dear Mike
I have been reading your wonderfully informative web site about radio. To the layman like me you have really opened the subject up and educated me- that's got to be an achievement.

Anyway, I am wondering if you can help me with a query. I am a falconer in the UK and I use radio tracking equipment to recover my hawk if ever it is temporarily lost from view. The telemetry systems available in the UK operate on either 173.225 MHz, 216 MHz or 433MHz. As far as I am aware the only legal telemetry frequencies for this kind of use in the UK operate on the 173.225 and 433 MHz frequencies which means that 216 MHz is illegal. However, because telemetry in falconry is a fairly recent innovation the first equipment available was on 173.225. This had a drawback because the antennas on the transmitters were a bit too long and when attached to the hawk would on occasion snag on wire fences or other obstacles pulling feathers out or worse still electrocuting the hawk if it landed on a power pole. When equipment on 216 became available shortly afterwards (late 1980's) many falconers switched to because the antennas were shorter and to protect their valuable hawks. Most did this oblivious (or dismissive) of the law. Since then manufacturers have begun offering equipment on 433 MHz but it has been slow to catch on particularly as so many had already got receivers and transmitters on the two other frequencies. A situation has now developed with the potential advancement of digital radio and there is a rumour in the falconry world that DAB may soon begin transmitting on 216MHz. Falconers with 216 equipment are worried understandably because they may have to fork out for new receivers and transmitters - the former are about £400 each and the transmitters about £100. Firstly do you know if DAB will be transmitted on 216MHz and if so will it affect the falconers analogue receivers? The obvious answer is that falconers on 216 should switch to legal frequencies I know but for now any help you could offer would be really helpful.

Darren Chadwick

Hi Darren,

Thank you for your e-mail and your kind comments. You raise some interesting issues.

The reason that the use of 216 MHz (or any other un-authorised frequency) is illegal is that the particular frequency in question will have bee marked by the government and Ofcom for a specific use, either now or in the future.

The illegal use of such frequency by low powered transponders may not currently cause undue interference to legitimate and licensed users, especially if the frequency allocation is used by only a small number of legal transmitters.

However 216 MHz has always fallen inside the legitimate 174 to 230 MHz 'sub-band' allocated by Ofcom to DAB radio. Ofcom are now in the process of expanding this band further, and as part of that process a new national network of about 170 high power DAB transmitters is due to be installed from next year (2008) onwards. This will use Block 11A - i.e. 216.978 MHz - in the DAB sub-band within VHF Band III.

Although I don't think that there is an allocation as yet, there is the possibility that Block 10D may also be used at some time, this is at a frequency of 215.072 MHz - just on the other side of 216 MHz.

I cannot say for certain if these DAB allocations will cause the users of illegal transponders problems, but I would think that there may be a chance that their reception would be 'wiped out'. Digital transmissions would appear simply sound like the "Hiss" of a de-tuned radio, so it's difficult to tell if you are receiving anything on an analogue radio. However these DAB signals will be quite strong and may be enough to make the very weak signals from the transponders un-readable.

All I can advise is be prepared for the worse. See what happens.

At least the legal 433 MHz equipment will use even smaller aerials!

I hope that helps.

Regards,
Mike

Hi Mike,

Your response has been the most detailed and factual yet. This information is exactly the news I was searching for. I am so very grateful. The only thing is, now that I am equipped with this knowledge I now have more work to do!

Once again so many thanks.

PS. Still not had a reply from Ofcom on any of these topics.

Darren Chadwick

See Also:

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DAB Radio

LOWE HF Series Receivers

Aerials & ATUs

Crystal Sets

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Amateur Radio QRP Projects

Thursday, 10 March 2011

3 Elements VHF Yagi antenna

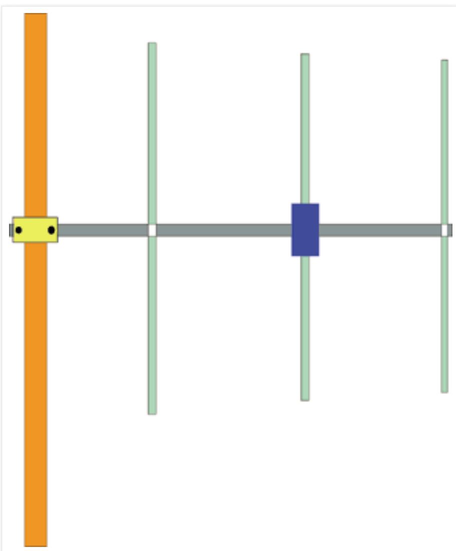

FIG.1 shows a 3 elements VHF Yagi "homebrew" antenna designed with YAGIMAX 3.

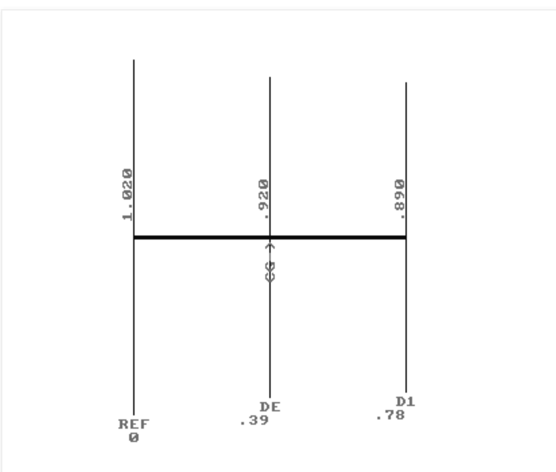

FIG.1
FIG.2 shows a table for the SWR, GAIN and F/B ratio.

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FREQ (mHz)	GAIN (dBi)	F/B (dB)	IMPEDANCE (ohms)	VSWR
140.000	7.78	12.21	24.92-j56.61	2.54
140.500	7.82	13.25	25.33-j54.10	2.31
141.000	7.85	14.34	25.66-j51.63	2.11
141.500	7.89	15.47	25.92-j49.18	1.93
142.000	7.92	16.63	26.08-j46.74	1.76
142.500	7.96	17.80	26.17-j44.29	1.61
143.000	7.99	18.91	26.17-j41.83	1.47
143.500	8.03	19.87	26.10-j39.34	1.34
144.000	8.07	20.53	25.94-j36.82	1.22
144.500	8.12	20.74	25.71-j34.25	1.11
145.000	8.17	20.47	25.42-j31.62	1.00
145.500	8.22	19.80	25.06-j28.93	1.12
146.000	8.28	18.89	24.63-j26.17	1.25
146.500	8.34	17.88	24.16-j23.32	1.40
147.000	8.40	16.84	23.64-j20.38	1.59
147.500	8.47	15.81	23.09-j17.35	1.81
148.000	8.53	14.83	22.50-j14.21	2.06
148.500	8.60	13.90	21.89-j10.96	2.37
149.000	8.66	13.00	21.27-j7.60	2.73
149.500	8.72	12.15	20.66-j4.12	3.15
150.000	8.78	11.34	20.05-j.51	3.65

The Normalized Radiation Resistance at 145.000 mHz is = 64.8 Ohms

FIG. 2

The maximum forward GAIN is about 8,17 DBi (6 DBd) on 145 MHZ. With 6 DBd (6 DBd = 8,15 DBi) gain, this antenna offering an **Effective Radiation Power** 4 times greater of the transceiver output (without Coaxial-Loss), i.e if you have a VHF transceiver with output Power of 50 Watts, your ERP will be multiplied 4 times = 200 Watts (in the forward gain direction). The antenna is compact enough (78 cm. Boom between Reflector-director) with excellent F/B ratio (20 DB) .

The Impedance on center frequency (145,000 MHZ) its 65 Ohms. If you connect a 50 Ohms coaxial cable directly to dipole, the SWR is 1.3:1

In practice the antenna needs a "matching system" for a 50 Ohms coaxial cable feeder (H-100, RG-213 or similar) in order to minimise the SWR ratio to 1:1##

I have used a "Hairpin" system (FIG. 3), which is very simple and effective "matching method". ***YAGIMAX antenna design program*** including a calculation-tool for the Hairpin's dimension, depending on "Data" of the table above (FIG.2)

The **Drive Element** is an **"Open - Dipole"** (two pieces of about "Lambda/4") with overall length ***0.92 m.*** (see FIG.1) FIG.3 shows the Drive-element (Dipole) and the Hairpin construction on the dipole's plastic box. Keep in mind, by using a Hairpin the dipole must be a bit-shorter than normal, in order to act as a capacitive-element (25.42-j31.62 at 145 MHz). Thus the overall length of dipole is about 92 cm.The space between the two screws is **2.2 cm** (dimension B) and the dimension **"A"** is **5 cm** for 1:1 SWR (on my antenna). If you have not the optimum SWR (1:1) we can increase (or decrease) the "A" dimension a few millimetres, looking for the minimum SWR.

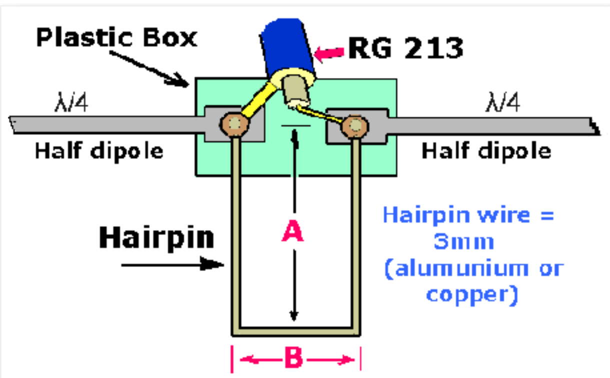

FIG. 3

The antenna is being constructed by using **15 x 15 mm** aluminium boom and I have used for the elements tubular aluminium rods of 8 mm diameter. If the elements are placed directly to the boom, without a plastic piece for isolation, the dimensions must be 5mm longer (Reflector = 1025 & director = 895). The plastic box which I have used for the dipole it was from an old TV-antenna.
*NOTE: if you place the antenna with Vertical polarization, the "center-cable" of Coaxial must be connected with the upper-section of dipole and the "shield" of Coaxial with the down-part of dipole.

Finally, the FIG. 4, 5 shows the polar-plots of 3 Elements VHF Yagi.

****

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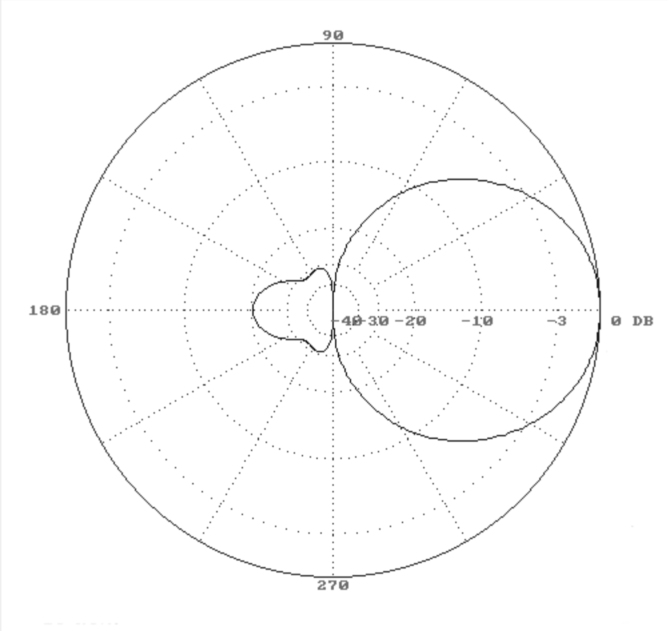
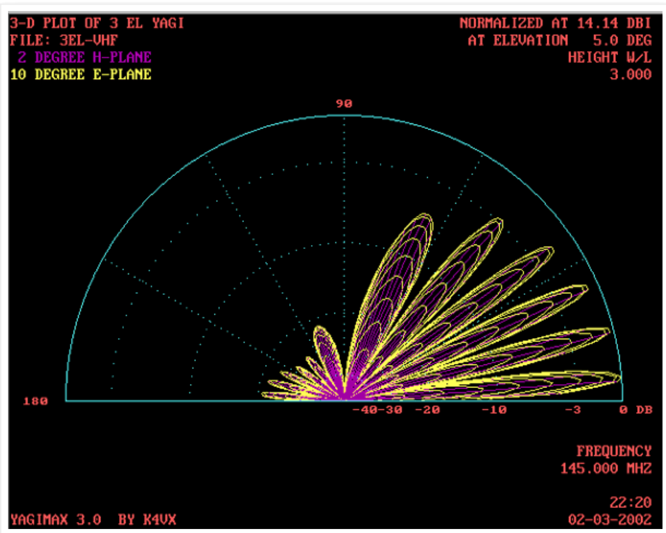


FIG.4



Posted by Selva kumar at 07:52

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40m Folded Radial Vertical Antenna

Rick Westerman, DJ0IP / G5BMH / NJ0IP

Introduction

Here is an antenna for people who have only a postage stamp sized back yard, yet would like to work DX on the low bands. The vertical in the example I show here was built and used successfully on 40m, but it may be scaled to 80m or even 160m.

Principle of Operation

The radiator and the total length of the single radial are both slightly longer than one quarter wavelength. See download for details. Although the elevated radial should be about 13 ft. high (for 40m), mine was only 10 ft. off the ground. It will work even lower, but 10 ft. is a good height to target. Minor length adjustments were needed on the radiator and radial to achieve best SWR at the desired resonant frequency.

Fundamentally this is a 2-dimensional vertical with just 1-Elevated Radial. The Radial runs in one direction for about 1/10 of a wavelength, then is bent 180 degrees, folding back on itself and running approximately 1/5 wavelength in the other direction.

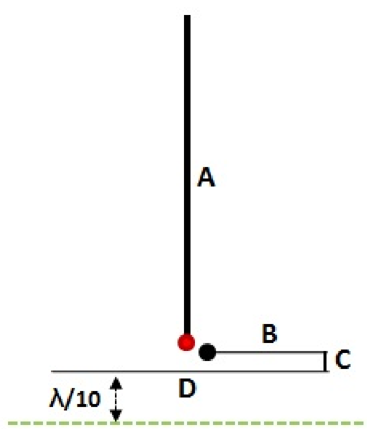
Construction

The basic design is shown on Figure 1.

DJ0IP's Dimensions

	Meter	Feet
A	11.50	37' 8"
B	4.05	13' 3"
C	0.10	4"
D	7.65	25' 1"
T	11.80	38' 8"

T = (B + C + D)



Theoretical Resonance*

Feedpoint Height		Min. SWR
Meter	Feet	MHz.
0.5	1' 8"	6.950
1.0	3' 3"	7.050
2.0	6' 6"	7.150
3.0	9' 9"	7.200
4.0	13' 1"	7.200

* Modeled with EZNEC+ Ver. 4.0

Feedpoint: 50Ω at the bottom of A and left end of B

Figure 1: **40 m Folded Radial Vertical Antenna**

Tuning: The antenna will have to be fine-tuned on-site. It is not "plug-n-play" with these dimensions. All dimensions affect the resonant frequency and ultimate SWR – even the height of the feed point – as seen in the table above. I spent one afternoon playing with all parameters to optimize the antenna.

Note: My resonance was lower than the model predicted, which is often the case.

Important: The antenna must be adjusted while measuring at the feed point – not in the shack. Use as short of coax cable as possible.

Tips: It is much easier to adjust this antenna using an antenna analyzer than the transmitter and SWR Bridge. It is probably difficult to change C, so play with the lengths of B vs. D when optimizing SWR.

The radial wire is spaced equal distance below itself (similar to open wire feed line), and extends about 1/10 wavelength beyond the vertical radiator in the opposite direction of the folded portion. A couple of broom sticks nailed to the fence will support the ends of the radial.

In numbers, this is about 13 ft. each side of the radiator (for 40m). Normally each 40m radial is about 33 ft. long! This one is intentionally longer.

As a result of being just two dimensions, this antenna can be installed on a property line, as long as there is no metal fence running along the line below it. In fact a 6 ft. tall wooden fence typically found in American backyards is perfect for erecting this antenna.

Believe it or not, this antenna radiates almost perfectly omni-directional!

I first saw a description of this antenna printed in RSGB's RadCom in about 2006 or so. I found it hard to believe it would work, so I did as I always do: I built it and tried it.

I took down my regular 40m vertical (a vertical dipole) and installed this "1-Arm Bandit" in its place. I then tested it for about 2 years, comparing it to my 40m horizontal dipole.

Both verticals were compared to the same 40m horizontal dipole, not directly to each other, so the results were slightly subjective, but the trend was very clear:

THIS ANTENNA WORKS!

My conclusion was that this antenna works very well, but not quite as well as the vertical dipole it replaced. However when working long-haul DX, it was consistently 1 to 2 S-Units better than my 40m horizontal dipole installed at 40 ft.

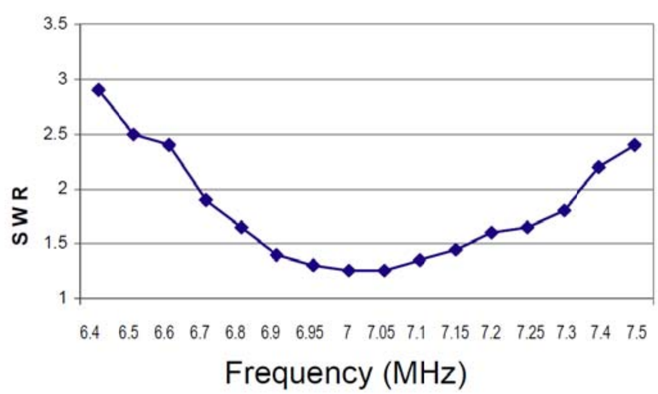


Figure 2: SWR versus Frequency

Conclusion

If you are interested in working low band DX and back yard space is scarce, this antenna is well worth consideration. Although its single radial is extended in a single plane, the antenna is still basically omni-directional. Keep in mind that minor tweaking of radiator and radial lengths might be necessary to obtain a good match.

Don't buy a radio; Build one!

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Where to Locate Hard to Find RF Electronic Components

We have all been there. You found a great schematic for a circuit you want to build. The only problem is that you are missing a few essential parts. This is doubly a problem for RF circuits, as many schematics reference parts that haven't been manufactured for decades, and other parts critical to all RF circuits are difficult to track down.

The goal of this post is to help you track down these parts, and understand suitable replacements for components no longer manufactured. I won't link to eBay auctions or suggest finding items in flea markets. While both are great places to locate hard to find items, neither can be relied on to have an exact part in stock and readily available at any time.

This is a living post, that I will update over time, and I welcome your input to make this a comprehensive reference.

Transistors

Model	Suitable replacement
2n2222	2n2219 or 2n2222a
2n3553	2n3053 or NTE473

Variable Capacitors

Mouser has a few variable capacitors available that are suitable for RF circuits, manufactured by Sprague Goodman. Here is a good general purpose cap with a range of 65pf - 320pf. Other sizes are available that are within typical RF application ranges. For their full range of products look here.

Crystals

Two common crystal types used in RF electronics are the HC49 and FT243 varieties. One great place to purchase individual crystals is http://www.af4k.com who has HC49 and FT243 crystals in many values. I'm also going to violate my no linking to eBay rule, as N4ESS has an eBay store with a huge stock of HC49 crystals in interesting values.

50 Ohm Resistors

50 ohm resistors are great for making dummy loads. You can purchase high wattage 50 ohm resistors from Jameco. Here are two that are particularly useful:
Resistor Metal Oxide 50 Ohm 5% 5W
Resistor, 15 Watt, 50 Ohms

Ferrite Torroids

Amidon manufacturers ferrite torroids in a variety of useful ranges for RF circuits. You can purchase these torroids on Universal Radio or direct from Amidon. Some schematics reference the no longer manufactured 63 mix, such as the FT 37-63. The 67 mix has replaced this, so look for FT 37-67 instead.

Other Links

Readers sometimes write in with additional suggestions on places to find RF components. This is a listing of sites that I have not personally shopped at, but may be a great resource for parts.

> Kits and Parts for toroids and other component needs.
> Fair Radio Sales for many RF components. They also have an eBay store linked from their site.

Do you have a website that makes any hard to find components readily available? Drop me a line so I can add your information to this page.

Last updated: Jun 18, 2014

Posted: Jul 12, 2013

Keyword tags: rfelectronicscomponentsvariable capacitorscrystalstransistorsresistors50 ohm

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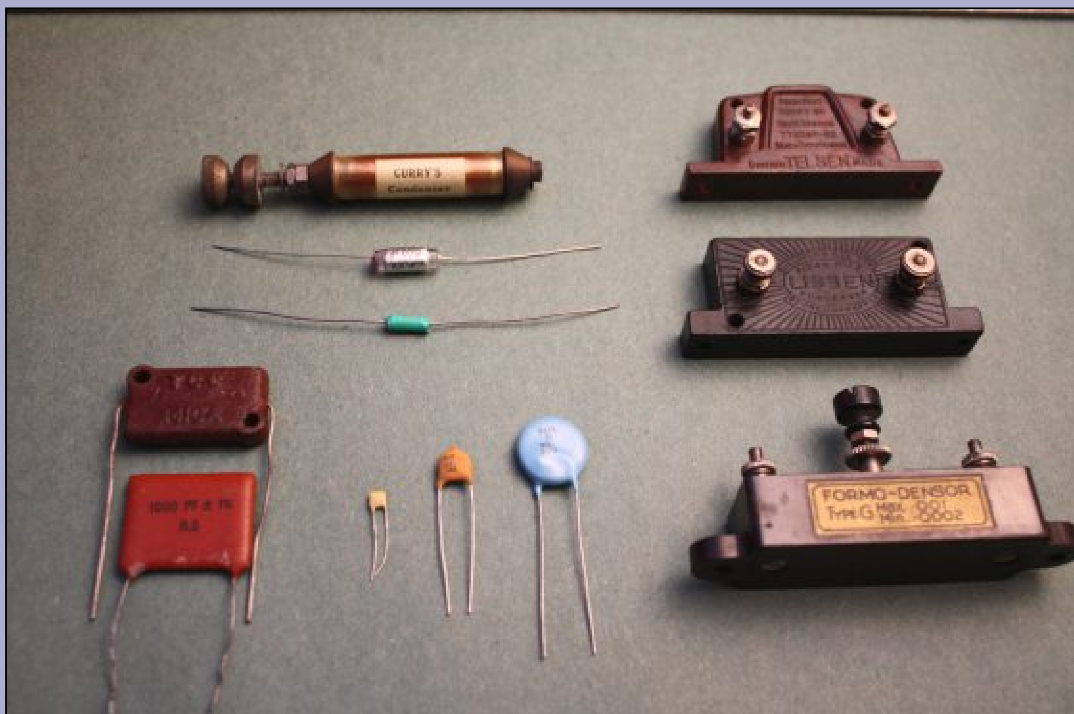

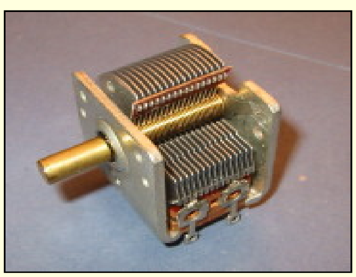

TUNING CAPACITOR 15-365pF. This is new manufacture. Supplied with two fixing screws. Shaft size is 1/4 inch Dia x 7/8 inch long. Larger View.

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Pacific Antenna 20 and 40M Lightweight Dipole Kit

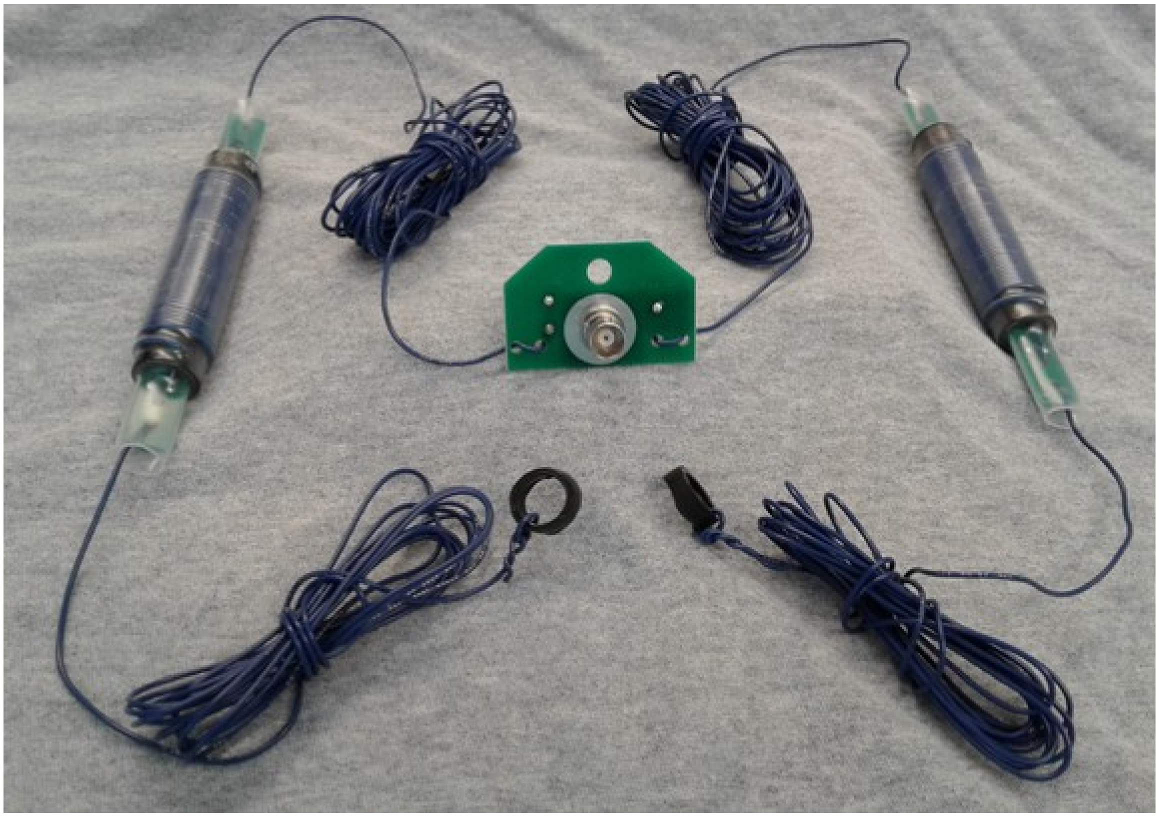
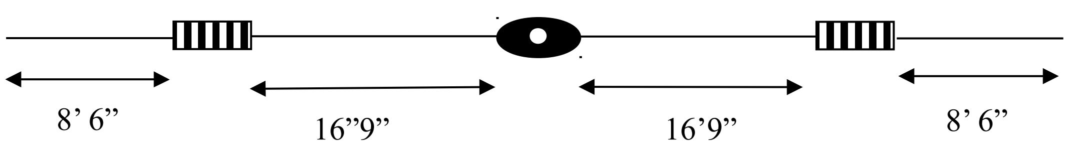


Diagram showing configuration and approximate lengths



Description

The Pacific Antenna lightweight dual band, trap dipole kit provides operation on both 20 and 40M bands.

Two capacitors in series serve to resonate the trap coil and isolate the inner part of the antenna for 20M operation.

On 40M, the traps act as loading coils and shorten the overall length of the dipole
Total length is approximately 50 ft rather than the 66ft of a full size 40M dipole.

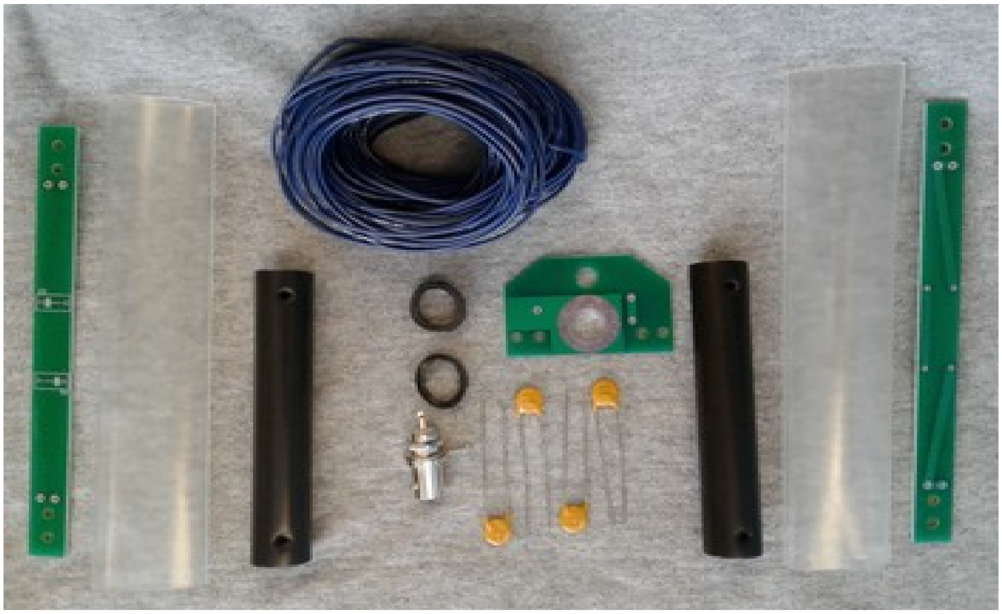
The dipole weighs less than 5 ounces and can be used at RF power levels up to 100W.

Recommended Tools

Wire cutter
Wire stripper
Soldering Iron and solder
Tape measure
Heat gun or other heat source for shrink tubing

Before you start

We suggest that you inventory the parts according to the contents list to be sure the kit is complete. If not please contact us for replacements.



Contents

72ft of #24 stranded wire
BNC connector (1)
Dipole center insulator PCB (1)
Trap capacitors PCB (2)
Coil forms (2)
27pF 3KV capacitors (4)
Clear heat shrink tubing (2)
End insulators (2)

1. Wire Preparation

Measure and cut the supplied wire to the following lengths*:

- 2 Sections each measuring 8 feet, 7 inches (outer antenna sections)
- 2 Sections each measuring 9 feet, 4 inches (coil windings)
- 2 Sections each measuring 17 feet (inner antenna sections)

These measurements include extra wire for making connections at the traps and center insulator and trimming to final length

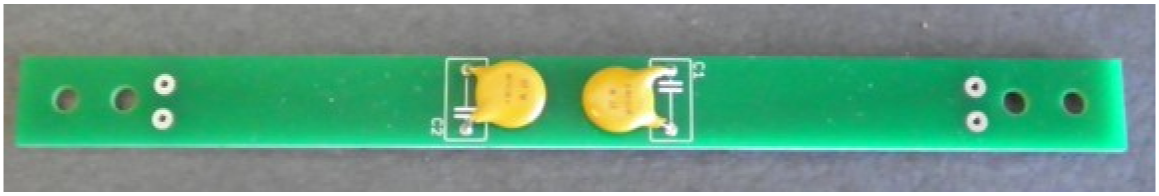
*Note: Measure carefully and double check the lengths of wire before cutting to reduce any errors. The old saying that applies here is "measure twice, cut once"

Traps

The traps are constructed from capacitors and an inductor (coil) to form a resonant circuit. Two 27pF capacitors are placed in series by soldering to the long circuit boards and connected in parallel with the loading coils to form the traps.

Trap Capacitors
Insert the capacitors into the long circuit boards in the marked positions.

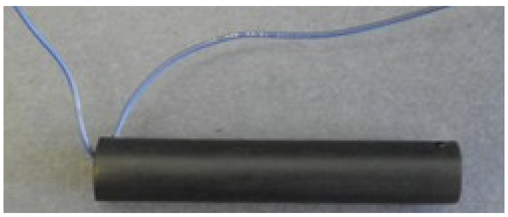
Before soldering, bend the leads over as shown below so that the capacitors lie flat on the board. This is to allow them to fit inside the coil forms.



Solder the capacitors and trim the excess leads so that the board appears as shown in the photo above.

Trap Coils
The coils use the 9’ 4” sections of wire that were prepared previously to wind coils with 46 turns.

Start by inserting the wire through one of the holes of the coil form leaving about 2”.



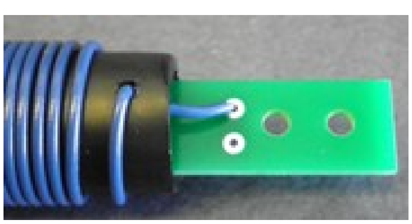
Wind the coils counting one turn each time the wire passes the starting point. Keep the wire as tight as possible and the turns together during winding.

You can tighten the coil by holding one end and with the other hand, twisting the wire on the form in the direction of winding to remove slack.

Double check by counting the turns to verify the total number of turns is 46 before cutting off the excess wire in the next step. A turn is counted as each time the wire passes the starting point as it wraps around the coil support tube.

Note: Tape may be helpful to temporarily hold the turns in place while winding.

Trap Assembly
Trim the leads of the coils to approximately 1 inch and strip the insulation leaving approximately 3/8 to 1/2 inch of the insulation past the coil ends as shown below.

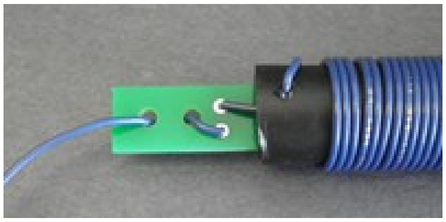


Insert the capacitor board into the coil form so that it is centered in the form, insert the stripped coil wire ends into the board and solder the wires to the boards.

Repeat this process with the other coil to complete the trap set for the dipole.

Antenna sections

Each trap will be connected to the end of one 17 feet and one measuring 8 feet 6 inch wire by feeding the wire through the outer hole, back through the next hole.



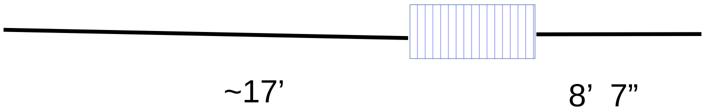
Strip approximately 1/4" of the insulation from the antenna wire, feed it through the solder pad hole and solder the wire to the board.

Pull the end of the wire to remove any slack and to hold the wire in place in the board.

Repeat this process on the other end of the trap with the complementary wire and then do the same with the other trap.

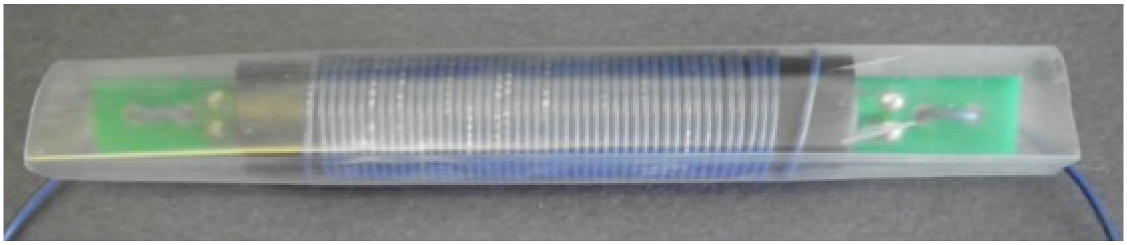
Each trap should now have the 17 ft wire attached to one end and an 8 ft 7 inch wire to the other to form each half of the dipole.

Note: The length includes everything up to the end of the coil so the actual wire may measure a bit shorter if measured from the end of the trap board.



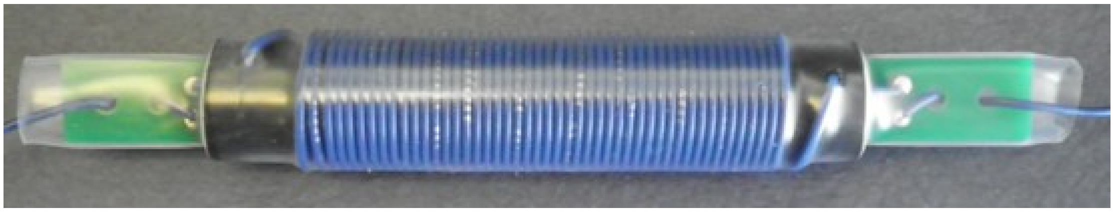
The 17' sections will be the inner part of the antenna and the 8' 7" ones will be the outer ends of the antenna.

Carefully slip a section of heat shrink tubing over each of the coil form.



If some turns of the coil become displaced or separated, use a small flat stick or tool to push them back in place before shrinking the tubing.

Shrink the tubing using a heat gun, or other heat source. Use caution to avoid overheating the coil form or causing injury.



A few tips on shrinking the tubing can be found here:
http://www.doityourself.com/stry/8-ways-to-heat-your-heat-shrink-tubing

Center Insulator

The center insulator circuit board has a large hole for mounting the BNC connector as shown in the photos below.

Place the star washer on the BNC and insert the connector in this opening in the circuit board.

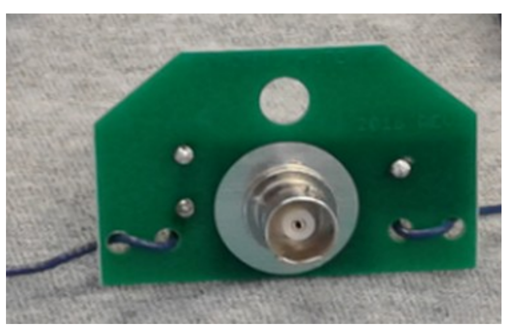
Place the nut over the threads and tighten to secure the BNC from rotation. You may find it helpful to use another BNC connector such as one on a feedline to help prevent rotation.

The connection to the BNC shell is made by contact to the circuit board and a short wire provides connection between the center pin of the BNC to the adjacent pad on the board.
This can be done with a small section of antenna wire as shown below.

Next, trim the 17 ft sections of the antenna to 16 ft 9 and 1/4 inches measuring from where it will be soldered to to the trap.

Feed the wire through the outer hole from the back side of the insulator (solder pin side) of the BNC connector and loop back through the inner hole leaving sufficient length to make the solder connections.

Strip the ends of the wires approximately 1/4 inch, push them through the board holes and solder to the board pads as shown below.



After the wire is soldered, the excess pull the excess back through the holes to secure the wire in place and prevent movement of the solder connections.

End Insulators

The kit includes a pair of insulators for connecting supporting string to the antenna ends that are formed from small sections of coil material.

Attach these by simply twisting or tying a knot the ends of the wire around the rings.

After final tuning of the antenna is completed, the wire can be secured to the insulators with tape or heat shrink to prevent slippage during use.

Tuning the Dipole

Depending on how the antenna will be used (height, configuration, etc) the length of the outer section of the antenna will likely need to be adjusted for best match on 40M.

The inner, 20M section will probably not need trimming in most cases.

It is recommended to try the antenna at a few heights and different configurations before cutting the wire.

Note: Before trimming, we recommend that you first try tightly coiling or wrapping up some of the antenna end. This electrically shortens the antenna and may provide sufficient effective shortening to provide a low SWR without any trimming.

First, set up the antenna in the chosen configuration (dipole, Inverted V, V, etc) and test.

Note: Configuration and height above ground will affect the match, especially on 40M.

An antenna analyzer makes tuning the antenna easier but it can also be adjusted by checking the SWR at the lower and upper end of each band.

If the SWR is higher at the highest frequency, then the outer section is too long.

If not, and tightly wrapping up a bit of the end does not improve the match, trim a small amount (1” or less at a time) from each side of the antenna and retest.

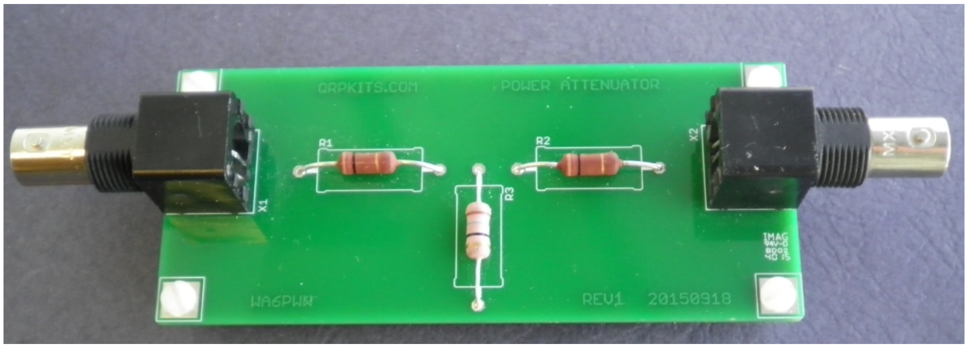
Note: It is important to test carefully and verify the need for trimming and be very careful not to remove too much and in most situations, it should not be necessary to cut the outer section shorter than approximately 8 ft 3 inches.

Congratulations, your Pacific Antenna 20 and 40M dipole kit. is now complete!

If you have any questions, please contact us: qrpkits.com@gmail.com

Thanks from the Pacific Antenna Team!

Resistive Attenuator Kit

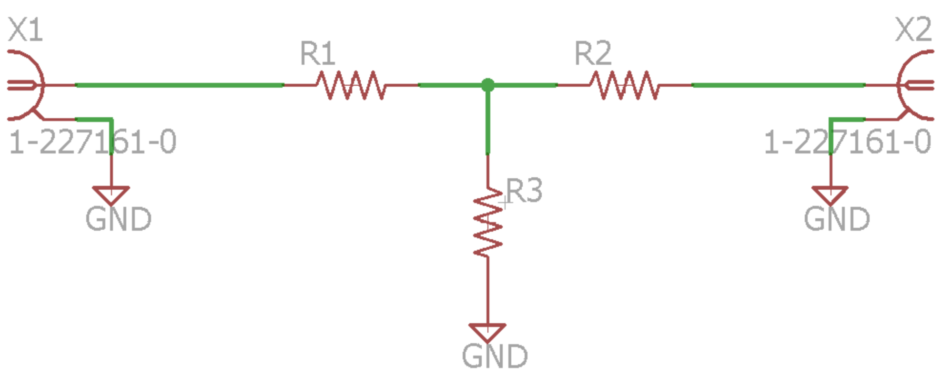


The Resistive Power Attenuator kit from Pacific Antenna provides an inline attenuator that may be configured for various attenuation levels.

The kit includes resistors for either 3, 6 or 10dB attenuation levels (specified when ordering) as well as BNC connectors and a circuit board.

All resistors are rated 3 W so that the attenuator can be used continuously at 5W levels and up to 20W for intermittent usage.

The attenuator is a T configuration as shown below.



Parts List

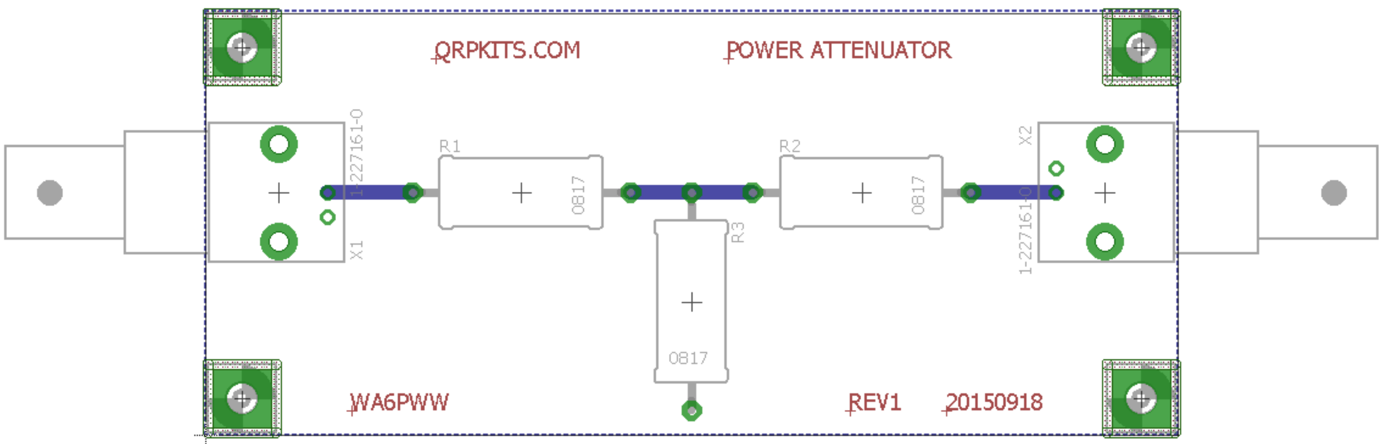
3	Power resistors, values depend on attenuation level
2	BNC connectors
1	PCB

Assembly requires soldering the two BNC connectors and adding R1, R2 and R3 as shown in the table below for the specified attenuation level. Note that R1 and R2 for each attenuation level are equal values and R3 will be a different value from R1 and R2.

Inventory	Installed	Quantity	Part #	Value	Color Code	Description
		1	R3	150Ω	Brn-grn-brn-gold	Resistor 3 W, attenuator, 3dB
		2	R1, R2	8.2Ω	Gry-blk-blk-gold	Resistor 3 W, attenuator, 3dB
		1	R3	68Ω	Blu-gry-blk-gold	Resistor 3 W, attenuator, 6dB
		2	R1, R2	15Ω	Brn-grn-blk-gold	Resistor 3 W, attenuator, 6dB
		1	R3	39Ω	Org-vio-blk-gold	Resistor 3 W, attenuator, 10dB
		2	R1, R2	24 Ω	Red-grn-blk-gold	Resistor 3 W, attenuator, 10dB

Simply install the resistors and BNC connectors as shown in the board layout below.

Check for any unsoldered connections, cold solder joints or shorts between pads. Otherwise, the attenuator should be ready for use.



This completes the attenuator kit.

It can be placed inline to reduce power from a transmitter or any other application where signal attenuation is needed.

UNIVERSAL FREQUENCY MARKER GENERATOR

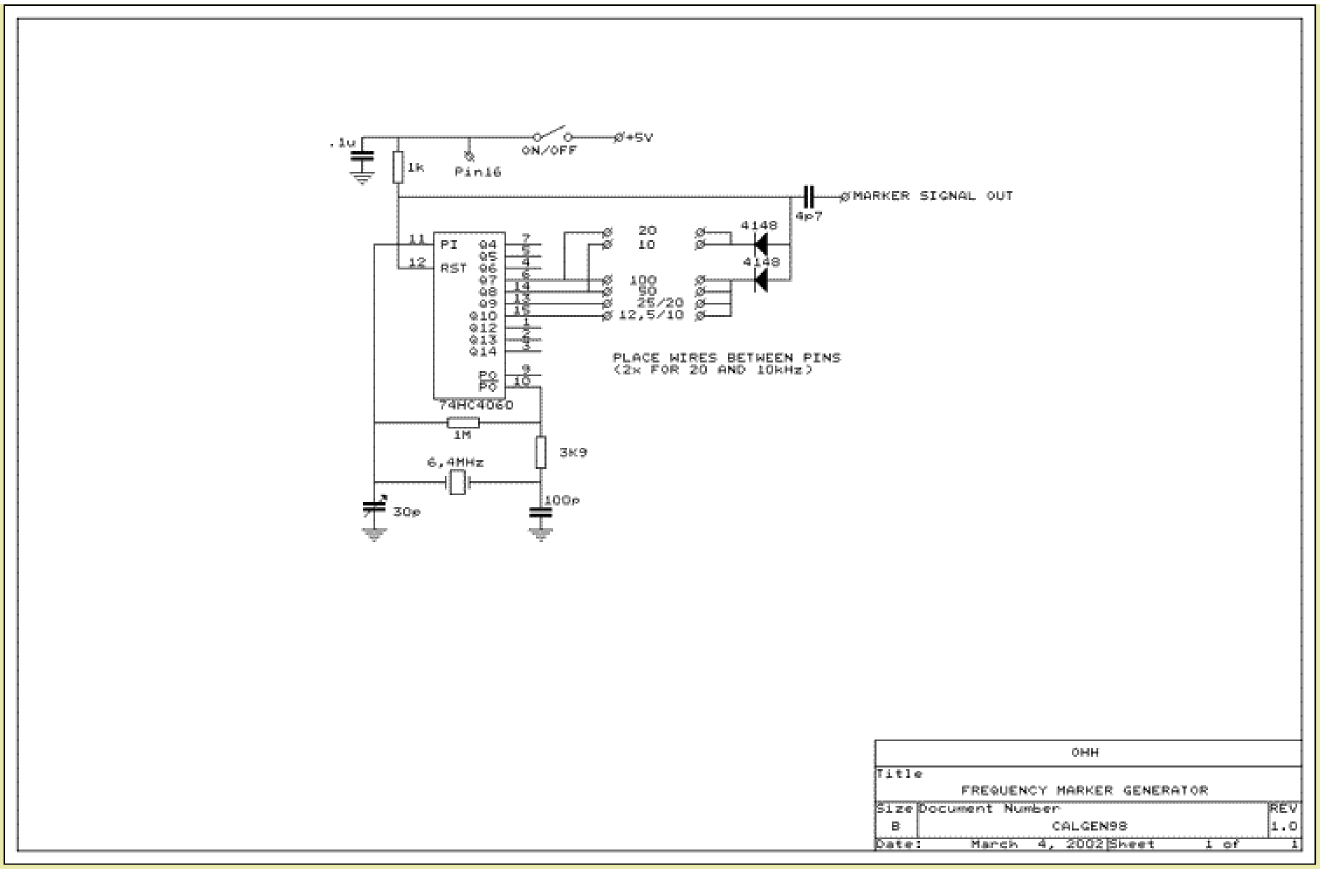
(1998)

KLIK HIER VOOR DE NEDERLANDSE VERSIE

Too cold for Simple Technology?
Check your frequency with this simple device.

Barefoot technology
This is also real barefoot technology or simple, cheap and harmless technology. Although not so actual anymore due to the frequency counters and synthesizers we have nowadays, this marker generator is a very simple and cheap device to calibrate your frequency.

What is a marker generator
A marker generator generates signals at all multiples (harmonics) of a basic frequency. If the basic frequency is for example 50 kHz, at all harmonics of 50 kHz a signal is heard when connected to the input of your receiver. As almost all amateur frequency bands start and end at a multiple of 50 kHz, this could for example be a very simple device to check if you are within the band. But if you take 10 kHz as the basic frequency, you can also calibrate the frequency scale of your QRP transceiver by marking the scale at each harmonic of the 10 kHz.
Another possibility is for skeds. If your frequency scale is not so accurate, choose your sked frequency near a marker signal so that you can tune exactly on the sked frequency.



Circuit diagram

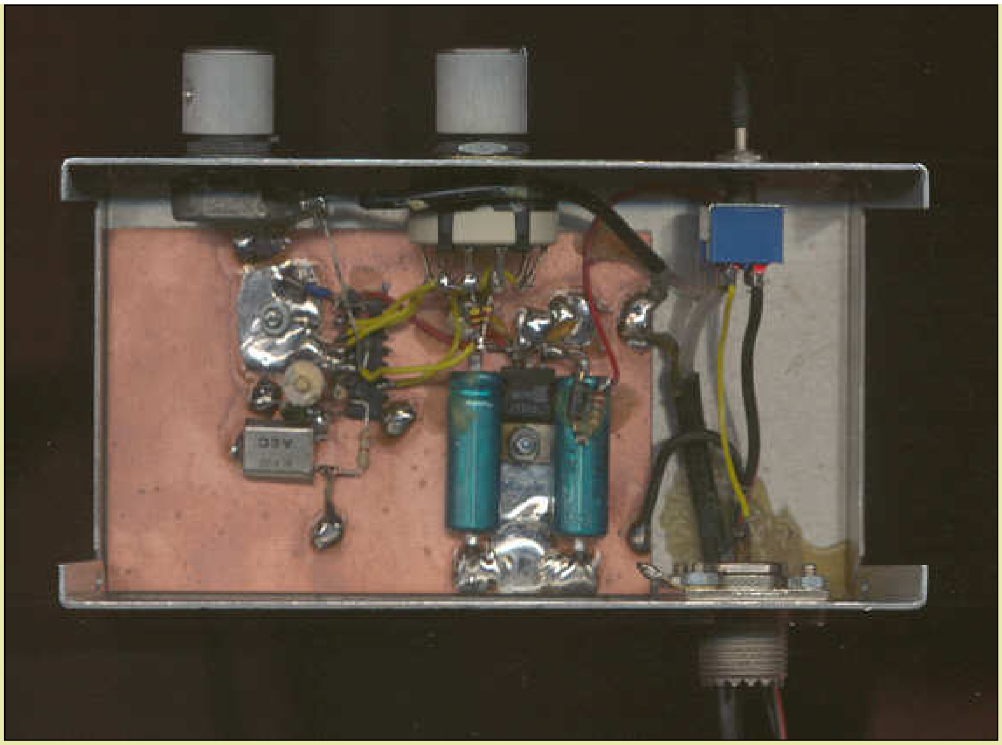
big diagram

How it works

The X-tal oscillator of 6.4 MHz (adjust it exactly to that frequency!) is divided to the desired basic frequency. As soon as the divider has reached the division value, selected with the matrix (wires connected to the pins as given in the schematic diagram, 2 wires for 20 kHz and 10 kHz marker signals) a sharp needle pulse is generated. The harmonics of this needle pulse are the marker frequencies.

Note:

Connect wires between the pins to set the desired basic frequency. There are 2 wire links needed for 10 and 20 kHz.
Add a potentiometer of 1 k ohm between the marker generator and the receiver if you want to control the level of the marker signals.



Inside

BACK TO INDEX PA2OHH

V.H.F. ANTENNAS - CONSTRUCTION AND USE

BY GEORGE PHILIPS VU2GT

INTRODUCTION

"A station is only as good as it's antenna". This is an unalterable truth which applies to any radio station irrespective of frequency of operation, kind of service or any other parameter.

The antenna launches electromagnetic energy into space from a transmitter or intercepts energy from a passing wave for further processing by a receiver. The antenna is the vital link between the station equipment and space which is the medium through which the signal is conveyed. Without a suitable and properly installed antenna, the best of equipment is of no use.

Antennas come in many shapes and sizes - from a simple dipole to very complex arrays - but all of them irrespective of shape, size and complexity follow the some basic principles. An understanding of the principles involved leads to a better understanding of the working of antennas.

There is no one antenna system which can be considered as best for all purposes but if one is armed with the necessary information, one should be able to - within the available resources - take the right steps to a successful antenna installation.

What then is the information required to choose an antenna intelligently, construct it properly so that it can weather the elements for a reasonable period of time before it requires an overhaul and install it successfully so that it gives you satisfactory performance? Without delving into the areas of antenna theory, wave propagation and transmission line mathematics, the following steps should enable you to reach the above goal. It should be noted however that since this discussion is restricted to VHF antennas the observations and statements are generally valid for the 2 meter band and above.

Step No.1

Determine what are the properties that you need in the antenna which you wish to install. We need to examine the following proerties.

a) **Polarization :** The aim of any 2 meter operator is see that his signals are received by other operators in his area and vice versa. Owing to the random location of stations it is essential to have an antenna with Omni-directional radiation properties. Besides, because of the widespread mobile use of 2 meter FM and the ease of mounting a vertically polarized antenna on a vehicle, the use of vertical polarization for 2 meter FM use has now become universal. Therefore the antenna under discussion would necessarily have to be vertically polarized.

b) **Gain :** The antenna should preferably have gain. There is no antenna magic by which the total energy radiated can be increased. However by narrowing the radiated pattern of the antenna to concentrate the radiated energy in a desired direction, the effective radiated power available at a desired point can be improved. This is how the gain of an antenna can be increased. In the case of the vhf band, normal propagation takes place by way of the ground wave and the space wave. Hence, our choice of antenna should be one that has maximum radiation at right angles to the vertical radiating element and none along it. We do not want our signals going vertically up into outer space - we want it to intercept the antennas dotted all around us.

c) **Bandwidth :** This is a measure of the ability of the antenna to perform without any deterioration of performance within a given band of frequencies.

d) **Impedance :** With the universal use of flexible co-axial transmission lines, the input impedance of the antenna should match the characteristic impedance of these lines viz 50 Ohms.

Now that we have defined the properties that we need in the antenna that we wish to install, let us now look at the different types of antennas that have some or all these properties.

Step No. II

Choosing the antenna :

The following are some of the vertically polarized antennas that one can buy or build.

1. **The 1/4 wave ground plane :** This is the simplest of all the antennas and consists of a vertical radiating element which is a 1/4 wave length long at the operating frequency. There are a minimum of 3 radials which are 5% longer than the radiating element and positioned at equal distances around the radiating element. The radials are normally bent at 45^0 degrees below the horizontal to ensure a better match for 50 ohms cable. The gain of the antenna is unity.

2. **The 5/8 lambda vertical :** This is a very popular antenna and widely used. The radiating element is 5/8 of wavelength long at the operating frequency. The radials are 5% longer than a quarter wavelength. An impedance matching network is required to match

the radiating element to 50 ohms co-ax cable. This antenna has an approximate gain of 3 db over a dipole and a reasonably low angle of radiation. It is possible to stack more than one 5/8 element in a collinear array with a proportional increase in gain. We shall discuss the construction of a single 5/8 lambda antenna in detail.

3. **The J Pole :** This is another very popular antenna which has the added advantage of not requiring a ground plane for its proper operation.

   This antenna however has the disadvantage of having a rather high angle of radiation. A variation of the J pole is the Slim Jim antenna which has a lower angle of radiation and hence a better radiation pattern.

4. **Vertically stacked dipoles :** The antenna consists of 4 dipoles stacked one on top of the other and separated from each other by a wavelength at the frequency or operation. This antenna exhibits an omnidirectional pattern if the dipoles are positioned at 90^0 to each other on the mast and has a gain of 6 db in this configuration. It exhibits a cardioid pattern when stacked one on top of the other and a gain of 9 db when assembled in this manner. This antenna is very popular for repeater installations.

5. **Collinear arrays:** This antenna consists of 2 or more half wave lengths operated in phase. When mounted vertically, this antenna has an omnidirectional pattern. It is not very popular as it becomes very unwieldy when more than 2 elements are used and because of difficulties in mounting the antenna vertically.

   The choice of a particular antenna from among the above would depend upon the individuals ability to build any one of them or the availability of commercially manufactured antennas.

   As far as simplicity, good performance, ease of building and low cost is concerned a 5/8 lambda antenna would be the best choice for both base station and mobile use.

STEP 3.

Transferring power form the transmitter to the antenna. With the universal use of commercially made equipment, the most convenient way of transferring power from the transmitter to the antenna is by using co-axial cable. The output impedance of all rigs being 50 ohms, the co-ax type to be used is either the RG 58, RG8 or RG213. All these types use solid polyethylene insulation between the centre conductor and the shield. Unfortunately the lower loss types using foam or air-spaced insulation are not yet manufactured in this country.

The loss figures per 100 feet at 144 MHz for the types mentioned above are as follows.

RG58 6db/100 feet
RG8/RG213 3db/100 feet

These figures would increase with age and also if the inner insulating material is exposed to moisture or chemicals. From the foregoing statements it is important to see that :—

a) The co-ax run from the transmitter to the antenna should be kept to the minimum possible to restrict the line losses.

b) Lower loss cables like RG8/RG213 to be used especially on the 2 meter band.

c) Connectors especially at the antenna or exposed end to be fitted correctly and precautions taken to water proof the joint to prevent entry of moisture into the cable.

The procedure to be adopted to fit various types of connectors to different types of cables is illustrated in every Amateur Radio Handbook and it would be worth every body's while to follow these instructions strictly for proper connection.

STEP No.4:

Installation: Now that we have chosen the antenna we wish to install and have either built or bought one, have acquired the right type of co-axial cable and have connected the right type of connectors at the ends, we are ready to install our antenna and fire the rig.

The higher the better within safety limits is the rule to be followed when installing an antenna. The best and the most convenient antenna mast is a full 20 feet length of C.I. water pipe which is readily available at all plumbers. A 3/4" or 1" diameter pipe of the smallest wall thickness viz A class should do the job admirably. Try and locate the antenna mast at the point where your cable would have the shortest run into the shack. Wherever possible use G.I. hardware for fixing your mast as they do not corrode like unprotected hardware and there is no danger of your installation coming crashing down at a later date. Provide strain relief for your cable by taping the co-ax down on to the mast so that the weight of the cable does not tug at the connector at the antenna end. Now that your antenna installation is over, connect up your cable to the rig and fire away! Happy hamming.

The Fredbox

2007-05-26

I first heard about The G3XBM Fredbox transceiver via Solder Smoke. As soon as I saw it I just had to give it a go. It is a very simple and elegant design. Of course it offers no bells or whistles, just a fixed TX and RX frequency, and a flea-power output on TX, but it has a special charm in its simplicity and the retro usage of AM on VHF.

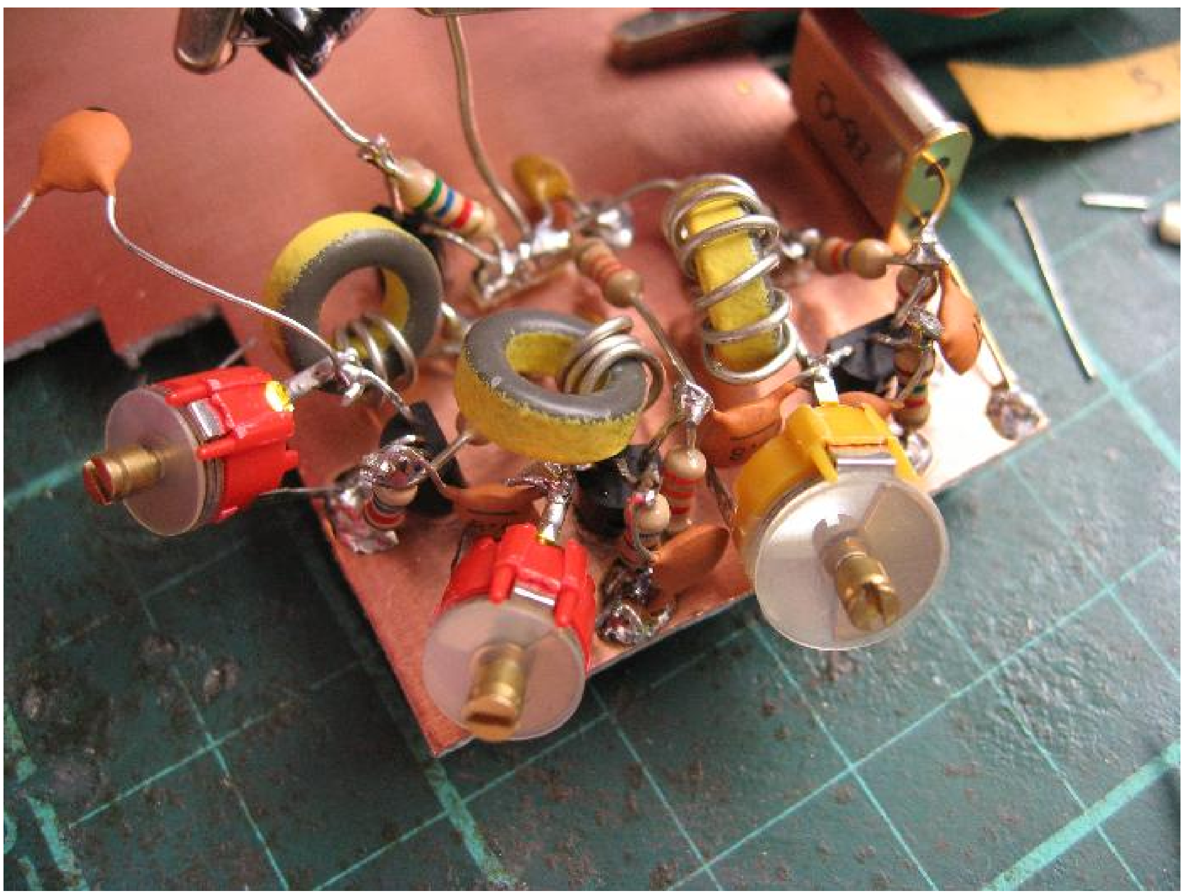
Transmitter

I built the transmitter side first. BF199s were selected as a good candidate for the RF devices, but I lacked a crystal in the range specified in the original article. Instead, I used a common 16.384 MHz crystal and redesigned the circuit to be two triplers rather than two doublers. This crystal is a common "computer" crystal, but places the TX frequency in the high-end simplex segment. This is a bit too close to the pager-splattered end of the band for my liking, and doesn't match the band-plans. For now this is OK, I'll get a custom crystal cut eventually.

I didn't use shielded cans or variable inductors for the transmit coils (as specified by the article), rather I used fixed inductances wound on T37-6 toroid cores with bare 0.71 mm tinned copper wire. My LC resonance calculator and nH inductance meter were enormously helpful in making the selection and testing of the tripler and output stage resonators. Each stage was tuned with trimmer capacitors.

It was amazingly easy to get the TX-side working, I just built each stage from the crystal to the final amp in turn, testing as I went. Each stage is well behaved and peaks nicely.

Peter VK2TPM could hear the signal at his QTH several kilometres away when I connected the half-finished TX board into my flower-pot antenna. The DC input power was about 23 mW, and no special attempt was made to match the output into the load, in fact the series trimmer in the matching network was absent at this point, just a fixed 12 pF capacitor was used for DC blocking.



Upon finishing the TX circuit I did experience a bit of RF pick-up in the microphone amplifier 2nd stage. A 1 nF capacitor to ground discouraged its RF gain and eliminated the problem. The 2nd AF amp stage is located immediately adjacent the crystal oscillator stage and was picking up RF directly. The effect was not audible, but was visible on the spectrum analyser as weak 16.384 MHz sidebands either side of the carrier. This wasn't causing feedback, just high-frequency modulation of the signal. If nothing else it proved the bandwidth of the modulator, which is perhaps a surprise considering the 100 nF decoupling on the modulated rail, however the output impedance of the series modulator emitter is so low it could deliver a few tens of mVs of HF ripple into that kind of load.

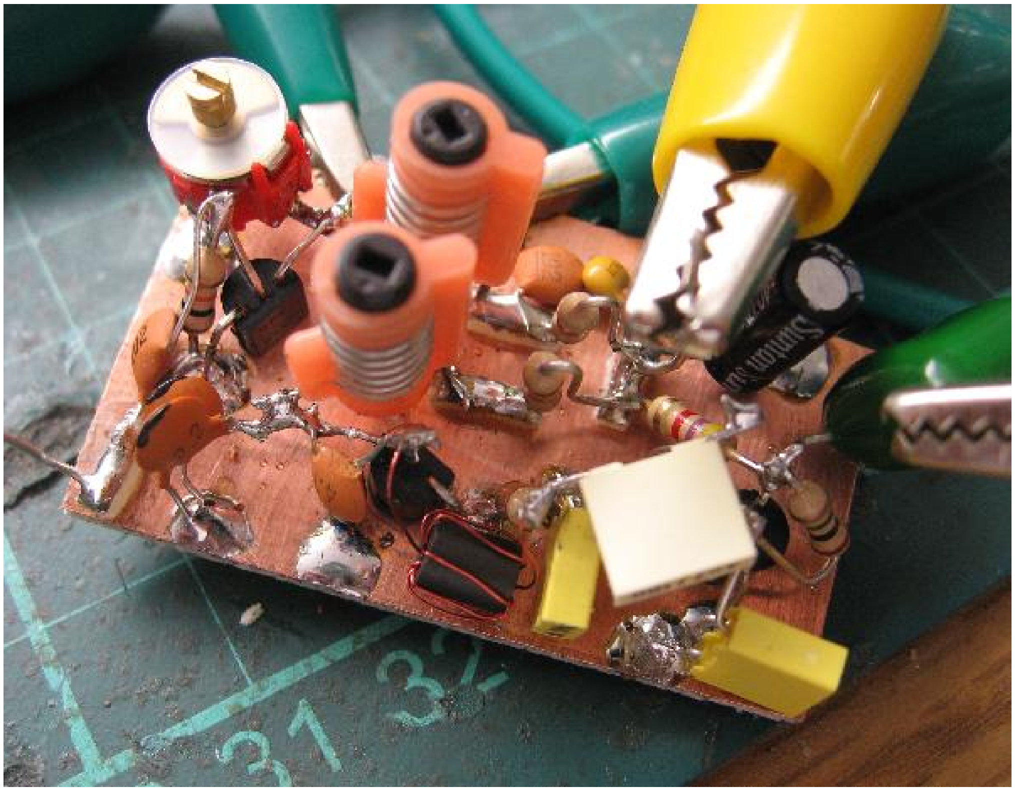
Receiver

As easy as the Transmitter was, the Receiver was hard. It fought me every inch of the way. I spent an entire day trying to work out why it was simply not super regenerating from about 130-160 MHz. It turned out to be a 10 nF decoupling capacitor on the cold-end of the detector resonator. The article specified 1 nF, and I originally intended to use this value, but I had a strip of 10 nF mono's on the bench, so I used them. At build time I did consider why 1 nF was specified in the first place, I figured it was avoid the exact problem that would befall my unit, decoupling resonance. (Lesson #1: Trust the original builder and your initial instinct.) When the unit wouldn't oscillate properly I assumed that I had damaged the capacitor on install - this is a pretty common fault, so I tested it in-place by ensuring it would shunt a HF signal (my standard decoupling cap test), it passed this test just fine. (Lesson #2: Test at the frequency of operation.)

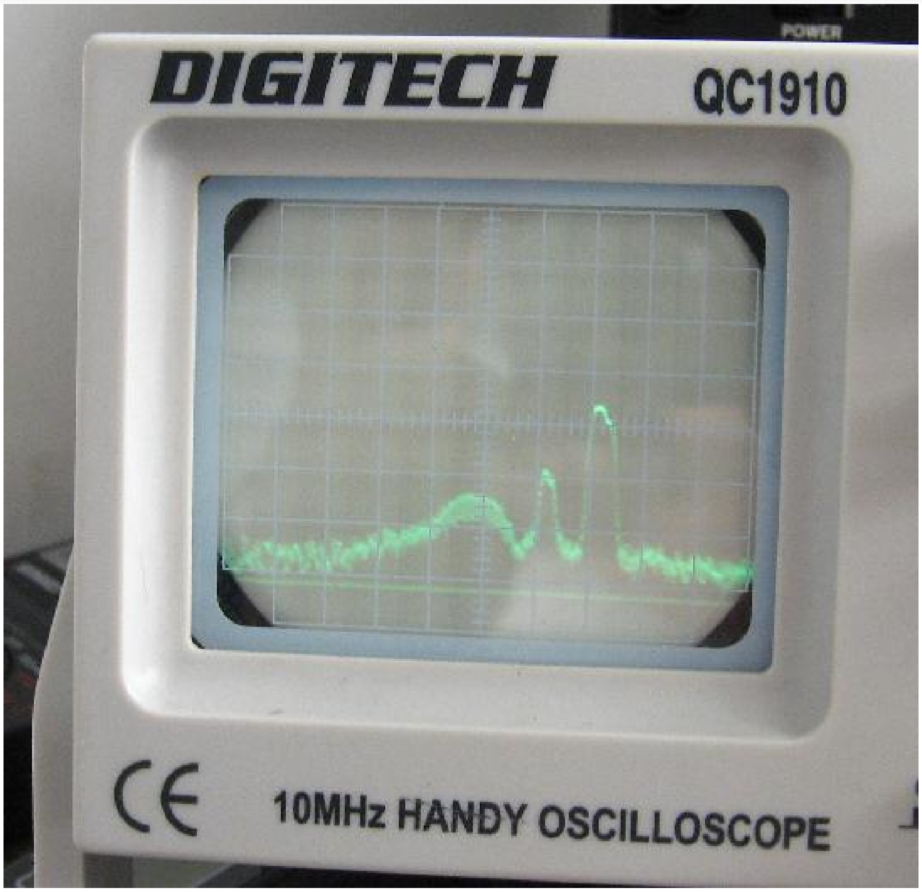
My hubris about "modern components" being superior and likely "purely capacitive" at VHF turned out to be completely wrong. It took *hours* to work it out, but eventually I determined the entire decoupling network was resonant near the operating frequency. Much foul language later and I replaced the cap with a ceramic 1 nF, with its "flashing" broken off and scraped right back to the disc to minimise the lead length. This cured the problem.

For the longest time I had assumed it was the source coil - and in fact the first source RFC I used (a molded choke) was being operated above its self-resonant frequency and prevented any oscillation at all. I replaced it with a few turns on a ferrite bead which seems just fine now.

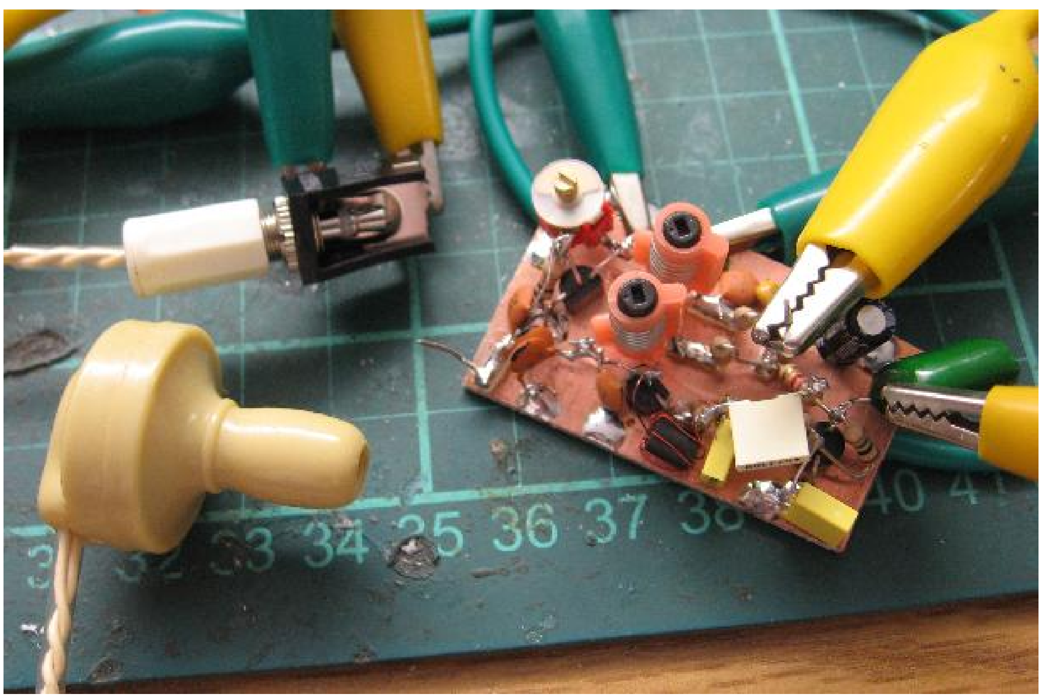
A couple of other minor annoyances/mistakes were worked through (like picking larger inductances and making the entire circuit so sensitive to stray capacitance it was a nightmare to tune - DUH!).



Eventually the unit super-regenerated right through the region of interest and the LNA stage was constructed. Initially I put the LNA drain coil too close to the detector coil and they over-coupled. This meant as I tuned through resonance on the LNA drain it would pull the detector so much it would shut down. Bugger! Moving the coils apart a little reduced this effect to acceptable levels, but the core of one still effects the other a little. I'm happy with the current coupling, and it is actually useful to help tuning the LNA resonator. As you rock it through resonance it will pull the detector, and by observing the wiggle on the spectrum analyser you can tell you've got it tuned up. The AGC action of the detector makes it hard to tune for maximum smoke otherwise, as the AF output doesn't change much at all even when the front-end isn't tuned up properly. Once you've got it nearly right you can use a weak signal to tune for best signal to noise.



Note the pagers above the 2 metre band in this spectrogram. The hump in the noise floor is the receiver super-regeneration side bands. The smaller peak in between is the output of the Fredbox transmitter, the leakage from the unshielded prototype on my desk operating into a 47 Ohm load. It is rather disturbing that the pager signals are *larger* than this local signal just a foot or two from the spectrum analyser antenna.



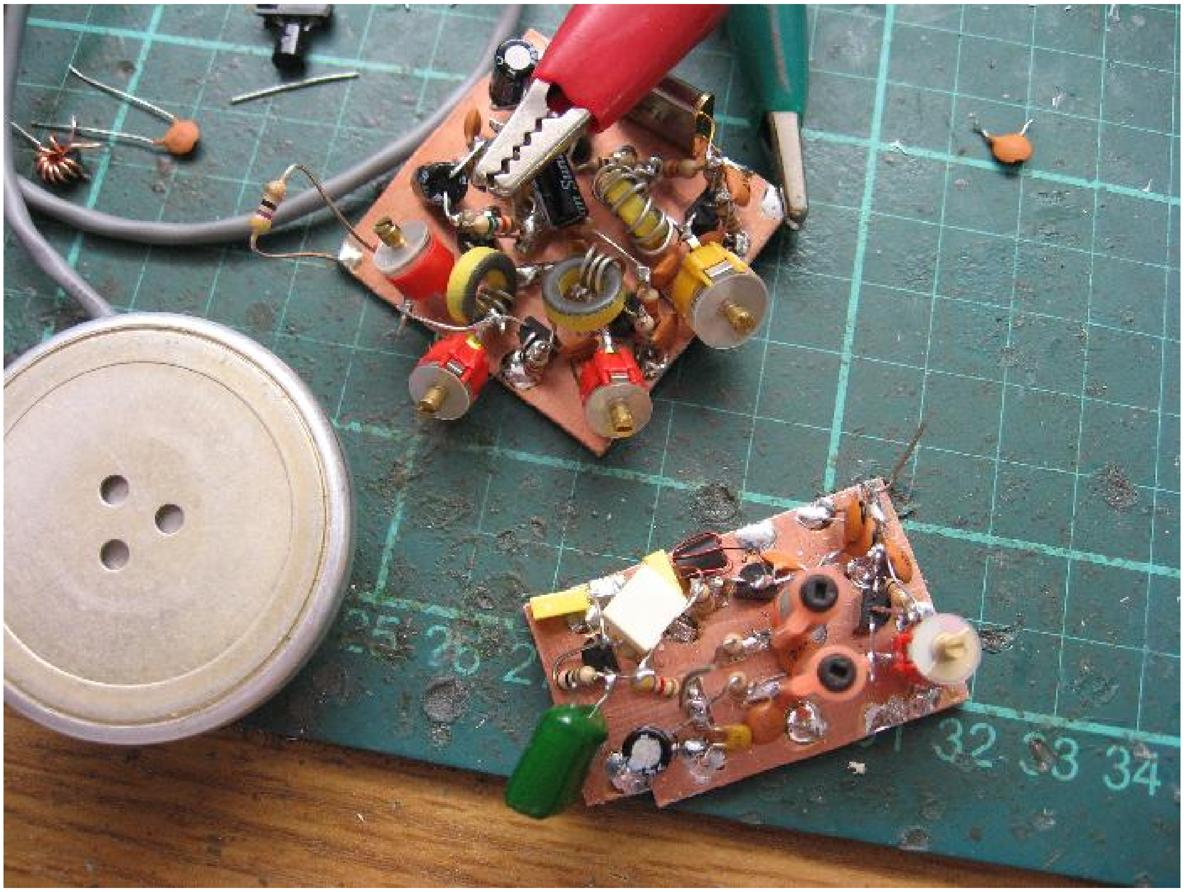
I used J310s for the receiver FETs, and a 2N3904 for the audio amp. Although the main design requirement for Roger appears to have been flea-power, I think a better AF amplifier that can drive modern low-impedance headphones would be preferable. Only [Jaycar](#) now carries crystal earphones with a nice soft silicone ear piece. The one I used comes from [DSE](#) and it is hard-plastic - not very nice on the ear. I really hate these kind of earphones anyway, I'll probably be rebuilding it for a low-Z output at some point, but it does work pretty well as-is.

BTW: While I was in the "Special Hell" of decoupling resonance I took the RX down to the FM broadcast band, and up to the VHF-hi TV band. It works wonderfully in both, which isn't a surprise. However, by adjusting the drain-source feedback (then a trimmer, now fixed) I

Hall's regen on the FM band. The topology is more forgiving however, allowing grounding of the tuning cap. I also built several different oscillator topologies in desperation before I identified the decoupling fault, in one I got a Colpitts-like oscillator working with emitter coupled feedback to a tapped capacitor across the tank. This is something I should have thought about a *long* time ago, I'll probably build yet another FM broadcast regen using this topology for the detector, it seemed quite easy to control just by manipulation of the base voltage.

Boxing It Up

I am still tossing up between a cast Aluminium box, a custom box folded out of Aluminium sheet, or an Altoids tin. The circuit is small enough to just fit inside an Altoids tin but it probably won't fit with a battery. I'll pick up a centre-off momentary-one-side switch over the next week and finish off the radio one way or the other.



Note the use of an old telephone receiver as the microphone. It is nearly as large as the entire TX board. I'll have to find my electret mics, I know I have a bag of them somewhere that I got from a Rockby sale.

I'm strongly considering rebuilding the radio, perhaps through-the-hole to minimise its size. Although my prototype isn't too large as-is, it would be nice to neaten it up. Maybe I'll build it with fixed caps and variable inductors to save space too, although shielded cans are about the same size. It *might* be possible to tune the multiplier stages with stretched coils and fixed caps, this would make it much more compact and save money too if it ends up being kitted...

More TX Power

I am considering running the unit on 12 Volts to get a bit more RF out, and perhaps building in a small amplifier to get it up to 1 Watt region. This would probably involve a rebuild of the TX side to use a 2N4427 or similar final device, and a more robust series modulator transistor. This won't be efficient, but is probably easier to get going than a linear amp which would need careful drive adjustment.

I'll probably conduct some experiments around using a 2N7000 or VN10KM as the output device. The math suggests they may operate on 2 metres. I've already got them working on 6 metres in a brief experiment last month (must document that).

Comments

Working with VHF is fun! I find it a great learning experience, especially when you get problems like the resonant decoupling cap. That kind of thing really pushes your understanding of the physics and teaches you a lot.

I know a lot of HAMs won't touch anything above the bandwidth of their oscilloscopes. I can understand the frustration when something doesn't work, especially when you can't see why, but it really isn't that much worse at VHF. With just a diode probe you can achieve a lot. It does help enormously if you have VHF test equipment, for example I likely would have never noticed the HF modulation problem had I not had a spectrum analyser (although the HF was visible on the collector of the modulator drive amp, and most of us have a CRO that can see fine near 16 MHz).

A wavemeter can be helpful, if a bit retro, especially for making sure your multipliers are tuned up right and for looking for spurs. You can build one quite easily, it only needs to be a resonator with a detector and a LED or meter as a read-out. I'm a big fan of the biased 1N5711 through the decoupled bottom of the tank coil topology. For super-sensitivity you can use a MPSA18 as a DC amplifier. With a signal generator or dipper and a counter or scanner/receiver you can easily calibrate it. It can be used like a poor-man's spectrum

My only advice when you get stuck is to trust the physics, do the math and follow your instinct when nothing is making sense. Rebuild parts of the circuit and test them independently. Measure what is actually happening and try to figure out what kind of misbehaviour in the circuit would cause the observed of behaviour. That will often solve an otherwise intractable problem.

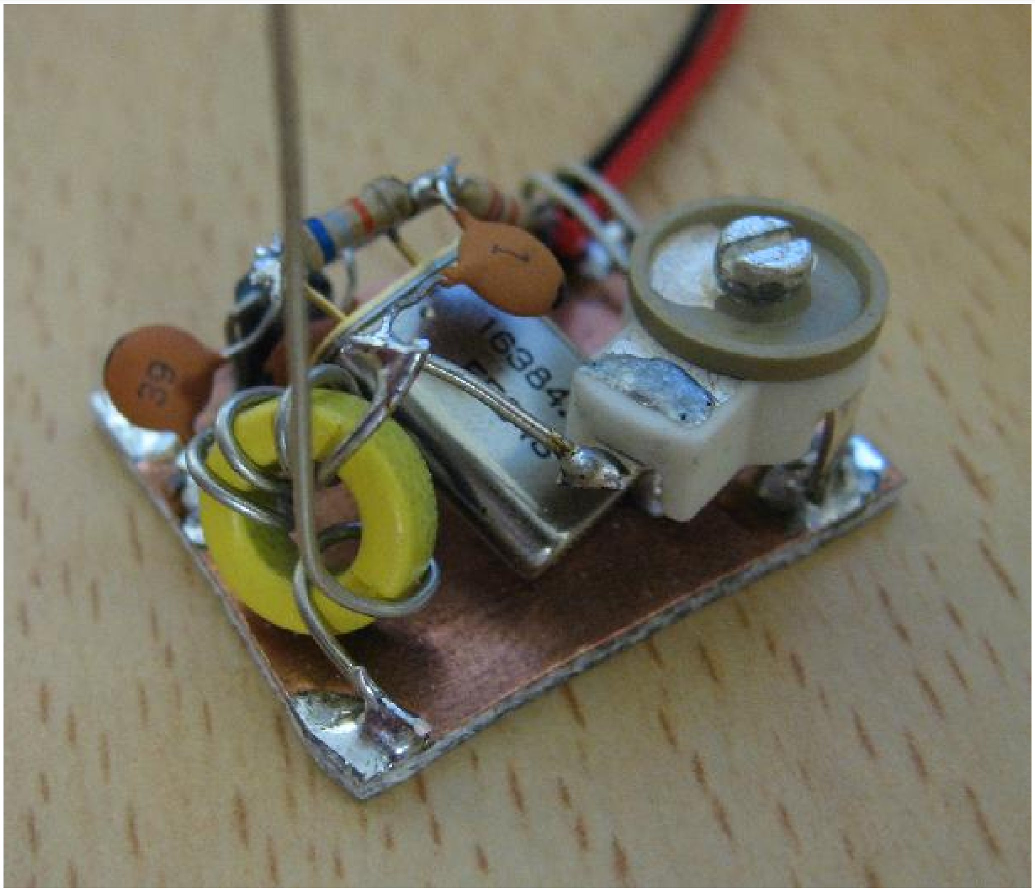
Update 2007-06-05

I took the Fredbox boards to the local Homebrew Group meeting. I had both halves hooked up and talking across the room. Peter VK2TPM had brought along a digital audio recorder and did an interview with many of us in attendance. You can hear what I said about The Fredbox on Soldersmoke 62, and even a brief snippet of audio going through The Fredbox.

Also on the recording are Peter VK2EMU talking about the 80 meter challenge, John VK2ASU talking about his transmitter modules for the challenge (and an interesting diversion into IRF510 gate-modulation with some input from Brian VK2TOX - something I was thinking about back here, apparently Drew Diamond VK3XU has already produced a design doing just this). Mike VK2BMR also talks about his great VSWR/power meter project. His unit was absolutely beautiful, I was very much taken by the excellent job he did of cutting the PCB stock that made up the external directional coupler box, essentially flawless, perfectly square workmanship.

Update 2007-06-09

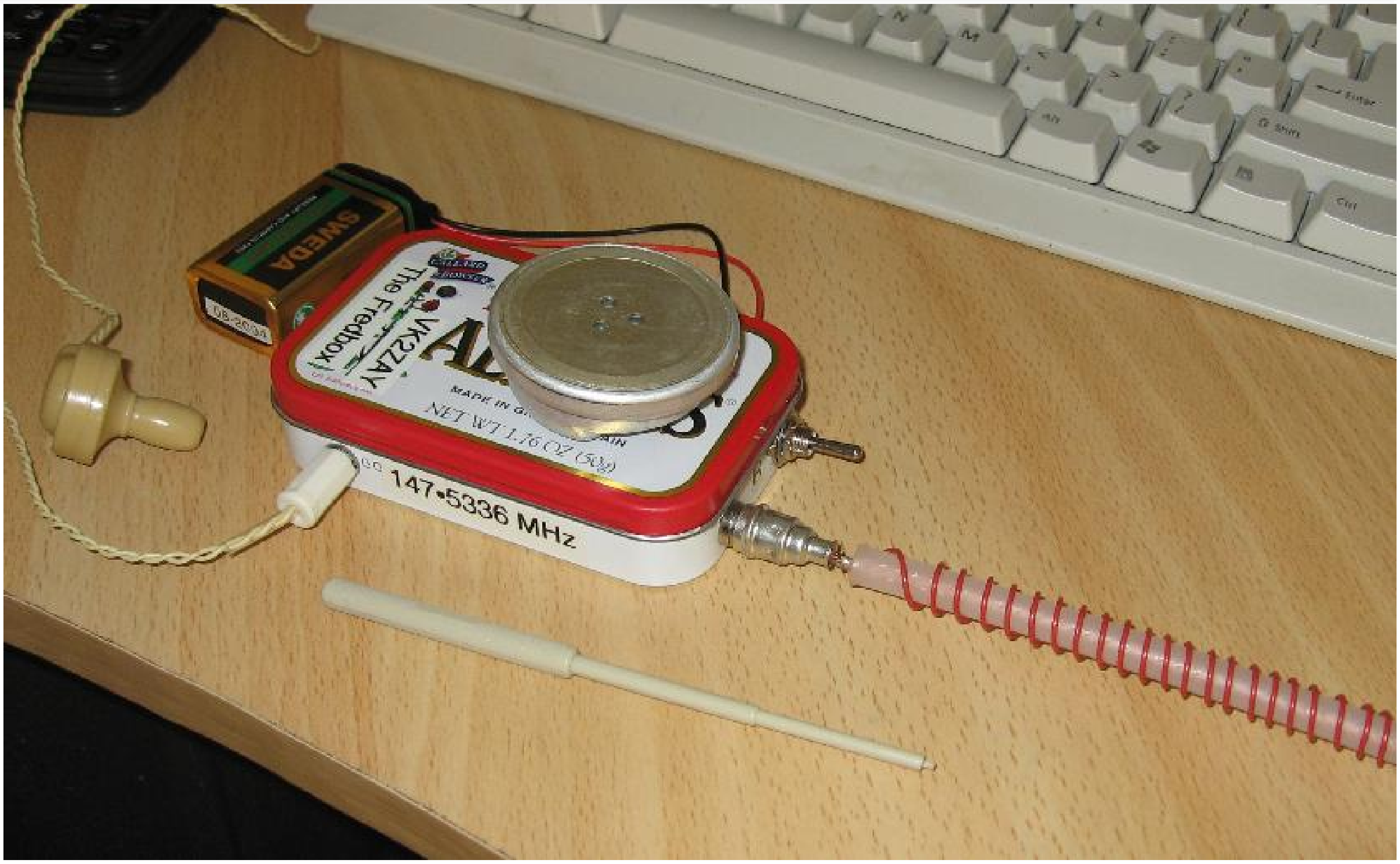
I've built a weak-signal source for aligning the receiver. One of the biggest weaknesses of the Fredbox receiver is that it drifts in frequency quite significantly with Vcc variations. Powered by a 9 Volt battery near the end of its life, it may drift enough to make the receiver completely off-frequency despite its poor selectivity. If I build this circuit again I'll probably put in a stabilized supply for the detector stage to avoid this problem.



The signal source is a Pierce oscillator driving a tuned circuit which selects the VHF harmonic of interest. Because of the oscillator topology the crystal isn't pulled down as much as in the Fredbox circuit. The difference is fairly minor for my purposes, the poor selectivity of the receiver makes the difference in frequency of no real consequence. There is no active (or passive) multiplier, so the tuned circuit is merely extracting the harmonic energy from the oscillator. The harmonic energy available is very small, which is perfect for the application, giving an almost undetectable signal 1 metre away.

Update 2007-06-10

I've boxed up the Fredbox. As discussed earlier I went with the Altoids tin, despite this not allowing the battery to also fit inside the enclosure. I tossed up soldering an additional tin to the back to hold the batteries, but for now I've gone with the 9-volt battery snap just hanging out. It will work well with 6xAA battery holders which can just be held to the box with a rubber band.



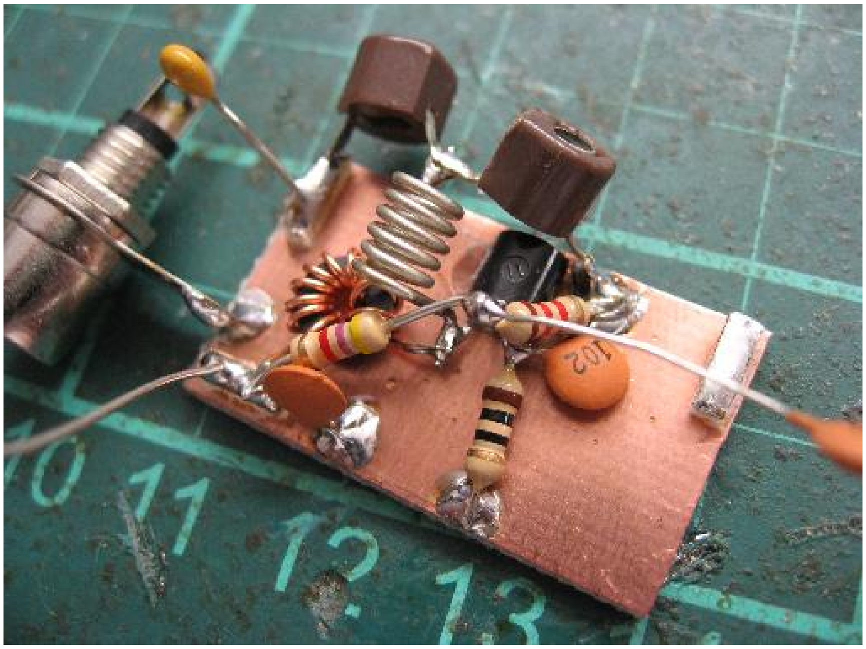
For the RF connector I chose an RCA. I can hear all the VHF engineers cringing, but for the purposes of this prototype it works just fine. The Antenna is a half-wave of wire helical which is quarter-wave resonant (with some pruning). The former is a piece of centre conductor and insulator from RG-213 coax. The centre conductor was left in place and is soldered into the RCA plug centre conductor, adding some capacitive loading and shortening the length of wire needed for resonance. I have no idea if this is good or bad, but it works.

I didn't find my stash of electret microphones, so I ended up just soldering the telephone receiver into the top of the Altoids tin. Ugly as hell, but also kinda unique. It looks somewhat like those Vietnam-war era VHF-low walkie-talkies.

I couldn't find a momentary-one-side toggle switch, so a centre-off on-both-sides switch was used instead. A special dummy load/diode peak-voltage probe was assembled for the final alignment. The carrier power ended up being near 25 mW on 12 Volts, on 9 Volts 10 mW just like Roger says in the article.

Update 2007-06-11

The 2N7000 on 2 metres experiment was a failure, it simply doesn't produce useful power beyond 90 MHz or so. However, it is very usable below 70 MHz. My input network was far from optimal, so perhaps with some more work it would be possible to get it working higher up, and I haven't tried an VN10KM in the same circuit.



I've also been fiddling around with grounded-base class-C multipliers. (Not just decoupled, biased base, the base actually soldered directly to the ground plane.) At first this seems a little weird, but if you pull the emitter low with a link-coupling to the previous stage collector current will flow. The advantage is excellent reverse isolation, which might help with stability with less than ideal layouts and devices. Such a topology was apparently quite common years ago with the 2N918.

1 comment.

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The DC-80

A Direct Conversion Receiver for 80 Meters with "subharmonic" VFO in the "Polyakov" style

July 15, 2009 by Rick Andersen, KE3IJ
[Revised February 23, 2010]

NOTE: I have revised this article to include some pictures of my prototype, originally ugly-construction-only, now installed in a Mouser Electronics plastic enclosure. I have also done away with the 600 Hz CW filter; the inductor picked up too much 60 Hz AC hum for my liking, even after I took measures to kill the hum. Instead of the previous 100mH inductor and .68uF series capacitor, there is now a single 10uF electrolytic cap connecting the output of the diode detector to the input of the audio amp transistor Q2. Rather than rewrite the article, I decided to ~~cross out~~ the revised sections, followed by yellow-highlighted comments on the revisions.

You may have noticed that almost all my receiver projects on these webpages, up to now, have been based on some variation of a **Regenerative Detector**, usually a Colpitts derivative. Most QRP designs over the last 30 years, on the other hand, have favored the ***Direct Conversion*** approach, which essentially means that we inject our incoming RF signal into one port of a mixer (usually a double-balanced diode ring) while injecting a tunable VFO into the other port, with *the VFO being at just about the same frequency as the signal we want to detect.* In such an arrangement, the **beat-** or **difference-** or **INTERMEDIATE-frequency (I.F.)** is reduced to (or close to) 0 Hz -- i.e., the beat frequency is at **baseband** and is the same as the **audio intelligence**, now demodulated. So, although we can describe the Direct Conversion circuit as a sort of "superheterodyne" whose local oscillator matches the RF input frequency and therefore has an I.F. of zero, it's more common to interpret it as a "non-superhet" without any I.F. at all -- we convert the incoming signals *directly to baseband* (audio); hence the name "Direct Conversion" (also called a *Synchrodyne* detector). This is not too different from a Regen detector, in self-oscillation, very close to the incoming signal frequency, producing an audible beat note. (Another name for a Regen is an *Autodyne* detector.) In fact, it can be said that the main difference between the two is that a Direct Conversion receiver has a separate Variable Frequency Oscillator (VFO) and RF input which are then combined in a mixer; in the Regenerative receiver, the mixer/detector/oscillator are all rolled up in one stage, into which the RF is coupled. And the Regen has legendary sensitivity, but it's also more sensitive to outside influences on the oscillating detector.

While the Direct Conversion (DC) receiver is thus conceptually very simple, it also comes with its own baggage (otherwise known as "Gotchas!") that can potentially make or break a homebrew receiver, causing an unnecessary amount of hair-pulling during the debugging phase.

I've tried designing a few DC receivers over the years. In the breadboard stage on the bench, they would often appear to work great... until I put them into enclosures or hooked them up to an electrically-unbalanced antenna like an end-fed wire. That's when the trouble usually began.

The two gotchas that most often caused me to go running back to my first-love (Regen receivers) were ***microphonics*** and ***common-mode hum***, which can dampen any enthusiasm you might have for DC receivers pretty quickly. Not to say that Regens don't have idiosyncracies of their own that must be dealt with or lived with. Choose your poison. But as I often say, that's the price we minimalists have to pay for our bare-bones toy radios. But we're not fatalists; we do try to come up with tricks to minimize the gotchas ;-)

"Microphonics" simply means that, since most or all of the approximately 100 dB gain of the receiver is in the audio stages [in contrast to a superhet, where most of the gain occurs at I.F., e.g., 455 KHz in an AM table radio], the receiver becomes very sensitive to mechanical vibration, like a microphone. So when you tap the case or touch a knob, you hear a thump with a bit of bell-like resonance to it. Any wiggling of the box that causes a micro-wiggle of the turns of the VFO's coil also gets amplified; turning a speaker amplifier up too loud may also induce acoustic vibration of the enclosure and cause audio feedback that can howl like a guitar amp if not controlled.

"Common-mode hum" is a much more difficult buggar to deal with. It's a nasty-sounding, raspy 120Hz hum that appears at various points across the tuning dial, usually at the frequency you're most interested in. The mechanism that produces it has to do with the receiver's own oscillator signal radiating back into the DC power leads and being rectified in the mixer -- or something like that (look it up in a textbook on DC Receivers; I never get the explanation quite right!).

It is exacerbated by connecting your DC radio to an unbalanced antenna system, particularly end-fed long wires, Zepps, etc., whose improper installation or inadequate RF grounding might also lead to RF in the shack while transmitting. A related symptom is that your receiver snaps, crackles, and pops with every electrical transient in the house wiring, like a refrigerator compressor turning on, lights being turned on and off, etc. Sometimes you may also find a tendency for the receiver's VFO to be "pulled" excessively as you rock your antenna tuning and loading capacitors back and forth through resonance (I use a resonant antenna tuner, rather than a PI network. I like the extra rejection of out-of-band signals that a resonant tuner gives me -- essentially, it's a bandpass filter in addition to being an impedance-matcher).

So what's a DC enthusiast to do? Well, the gurus' advice to us is to:

1) switch to a balanced antenna like a center-fed dipole (I use an 80 meter full wave horizontal loop nowadays; no more trouble with electrical pops and clicks originating in household appliances)

2) try to run your QRP equipment on batteries rather than AC-powered DC supplies or "wall-warts" (I use batteries almost exclusively, yet I could still hear common-mode hum at various spots on the dial. Also, I've found that most DC power supplies that are considered "well-regulated" are just a disaster when used to power the DC receivers I've built. With all that audio gain, what little 120Hz ripple residue there is, riding on that "pure" DC output, gets highly amplified by the receiver's audio stages.)

3) put "common-mode choke" toroids in the DC power leads to present a high impedance "open circuit" path to the common-mode hum energy (didn't work very well when I tried it)

So.

This is where I can begin my story that led to the new DC receiver described in this article, which I've named the "**DC-80**."

Some years ago I was sitting at the bench, trying to design a DC receiver for 80 meters, a band I tend to favor (relatively easy to design simple equipment for this band). For my "VFO" I was using a bench RF signal generator in the usual way: tuning it between 3.5 and 4.0 MHz, which worked just fine except for the microphonics problem that I outlined above.

At some point, whether by accident or intentionally -- I can't remember -- I switched the signal generator to a lower frequency range, turned the tuning dial, and was somewhat surprised to hear some very crisp, clear SSB banter in the phone portion of... what?... the 160m band?... because the dial was set at 1.9 MHz or so. Then I realized that the front end preselect filter I had installed between my antenna wire and my diode product detector, was tuned for the *80 meter band*.... were these 160m signals blasting through the 80m filter THAT loud and clear?...

Within a few minutes of listening to the SSB'ers yammering, I was able to identify them as operating on 75 meters, not 160! I pondered this for a minute, then thought "Oh! Maybe I'm mixing a harmonic of the 1.9 MHz generator signal, not the fundamental itself, with my incoming 75m SSB stations... The second harmonic (a.k.a. "first overtone") of 1.9 MHz is 3.8 MHz, and 3.8 MHz is in the 75 meter phone (voice) band! This is kind of neat!"

Well, what was also neat was that I couldn't hear any microphonics at all, with my VFO being at precisely 1/2 normal frequency. And, being set at "160 meters" frequencies rather than directly at "80 meters", the tuning knob was less "touchy", less prone to drift, too. Very cool.

And it got late that night and I hit the sack, and that's where I left my little discovery, until recently.

The Polyakov Detector

In June of 2008, I had an email conversation with Jerry, K9UT, who had built my AGC-80 Regen and wanted me to think about a 40 meter version of that project. He also mentioned that he had been reading about DC receivers whose VFOs were set to operate at 1/2 the normal frequency, and the benefits of that configuration. As I was working on my AGC-80/40 at the time, I filed his remarks away in the back of my mind and forgot about them for the time being.

Over the past few months of 2009, I've been reading here and there about a neat little circuit called the ***Polyakov detector***, which is the circuit that I think Jerry was referring to. Also called the "Russian mixer", it is described by RA3AAE (and/or others), in its simplest form, as two antiparallel diodes (i.e., two diodes soldered together in parallel, but with their cathode bands in opposite directions). Rather than needing any broadband transformers driving them, the simplest version of the circuit has them driven by incoming RF, on one end, through a 100pF capacitor. The other end is sometimes broken apart so that a 500 ohm pot [for nulling out AM 'blanketing'] can be inserted between the two diodes' right ends; the tap of the pot goes to another 100pF cap which is the VFO injection cap (VFO energy enters the diodes through this cap); simultaneously, audio energy (the beat frequency between incoming RF and VFO) is sent out from the same point and into an R-C low pass filter which removes the RF energy and mellows the audio somewhat. From there the audio is amplified, etc. (Other, more elaborate variants of the circuit do involve broadband transformers with multiple windings.)

Further Internet surfing informed me that this circuit concept has been around for a while, and the part that makes the Polyakov detector unique is that the VFO driving it is supposed to be running at ***half*** *the desired RF input frequency*... the Internet sources call this a "subharmonic" mixer. And the hams and QRP tinkerers are talking excitedly about the Polyakov circuit because it apparently solves the microphonics, frequency-pulling, and "touchiness" problems of the DC receiver, to some extent, because the VFO is running at only half the usual frequency; hence, it is more stable!

While I was in that netherworld between reading about it, and getting up the gumption to go down to the shack and actually try *building* one, I pondered the actual mechanism...

Was it really the '2nd harmonic' of the VFO at 1.9 MHz that was mixing with the incoming signal at 3.8 MHz, which was the 'magic' behind this circuit's performance? Why does 2nd harmonic mixing automatically "isolate" the VFO fundamental frequency from the RF signal in such a way as to suppress microphonics, etc.? Anyway, does the presence of a 2nd harmonic mean that the VFO signal is "dirty"? Because I would expect the 2nd (and subsequent) harmonics to be several dB down in amplitude, from the fundamental, and that the injection level wouldn't necessarily be adequate for that nice, loud, crisp detection I heard during my lab bench experiment. If my VFO is too "clean", will the circuit fail to detect?

Or does even the "cleanest" VFO output sine wave get mutilated by the mixer diodes -- i.e., Does this "2nd harmonic" really originate in the mixing process of the diodes themselves, via their nonlinearity? The explanations of the Polyakov circuit that I saw attempted to correlate the dual-directionality of the two diodes with the "doubling" effect, sort of like a full wave rectifier.

Then I pondered another question I've always thought about, but have never seen a clear answer to: If I mix two frequencies in a diode mixer, unbalanced, I know I will get four freq's out: f1, f2, f1+f2, and f1-f2. The question is, do all these new frequencies also automatically mix with one another, generating higher-order mixer products (I believe they do)... so where does this stop? It would seem that the original mix would "snowball" into a near-infinite number of new frequencies being generated in the mixer...but each new frequency having less amplitude, so that the majority of the snowball would be down in the mud, for all practical purposes.

...which brought me to another thought: Hold on a minute; maybe this isn't about "harmonics" at all; instead, maybe this is about *pure **heterodyne** mixing!* After all, if I mix a 4 MHz input with a 2 MHz VFO, both being pure sine waves with no harmonics contaminating them, then our sum and difference frequencies are going to be 4+2 = 6 MHz, and 4-2 = what?...2 MHz!

In other words, the beat frequency between any frequency and its half-frequency, is *another copy of that same "half-frequency"* (i.e., its "phase conjugate"). So maybe a Polyakov mixer is not really a "subharmonic" mixer after all; maybe it is simply exhibiting a regular ol' heterodyne process where the "beat" happens to match the lower of the 2 input frequencies. In other words, a "superhet" whose local oscillator is half the input frequency, and whose "I.F." is therefore *equal to the "local oscillator" frequency*. And when THOSE TWO frequencies beat in the diode, 2 MHz minus 2 MHz = 0....Lo and behold, the output is baseband -- in the audio range!

To test this idea, I built the simple RA3AAE circuit. Then I modified it in at least 3 ways, which led to the DC-80 receiver described later in this article. The test was: Will any other, NON-Polyakov mixer perform in the same way, with *f* and *f/2* applied to their input ports?

The Polyakov circuit

It didn't seem to matter where the 500 ohm pot was set; the AM bleedthrough was still there, although centering the pot lowered the overall volume of *all* signals, desired and undesired. I'm unimpressed so far. I did try a different null pot value (1k), put it on the other end of the diodes where the RF comes in, and various other things. It worked, but not as advertised, or so it seemed to me.

A Single Diode

I took out one of the diodes. Guess what? As long as there was a resistor to ground for continuity through the diode, the circuit worked as a "normal", single-diode AM detector...*even though the VFO was running at half-frequency.* This leads me to believe that my "heterodyne" idea is correct, and that it's not necessary to have two diodes connected antiparallel, to get the "doubling" effect [which is a misnomer, in my opinion]. AM bleedthrough, however, was objectionable, which is why decently-designed Direct Conversion receivers usually use a double-balanced, 4-diode ring mixer, along with a diplexer (impedance-matcher which properly terminates the RF and suppresses it from getting into the audio amp, which can cause unwanted "AM blanketing" detection in the audio transistors' base-emitter junctions).

A 2-Diode Product Detector

Next, I tried an old product detector configuration I'd seen in the ARRL Handbooks: Solder two diodes in *series*, but in opposing polarities; put RF in the left side, take audio from the right side, and drive the junction in the middle (through a cap) with VFO energy. Well, you need terminating resistors on each diode to make this one work right. Once again, the 2-diode product detector worked well as a 3.8 Mhz detector whose VFO was running at 1.9 MHz. But still some AM bleedthrough.

A New 4-Diode Detector

Finally, I tried something that I haven't seen anyone do before: Strap another 2-diode product detector in parallel with the first, but with the relative polarities of the second set of diodes *opposite* to those of the first set. So now we have 4 mixer diodes, not chasing each other as in a ring mixer, but as 2 "series" product detectors, of opposite polarity, in parallel (see the schematic of the DC-80, below). It can also be described as 2 Polyakov detectors connected together with the VFO injection at the junction between them. (The 500 ohm balance pot is eliminated.)

I call this a ***4DPD*** [4-diode product detector] **mixer**.

And it works very well. With VFO at half the RF input frequency. So when I call this a DC receiver with a "subharmonic VFO in the Polyakov ***style***" up in the title of this article, I'm aware that it's not an actual Polyakov receiver; instead, it's based on the spirit of the Polyakov mixer, especially with its half-frequency VFO. A run-of-the-mill doubly-balanced ring diode mixer, it ain't. But it performs nicely just the same.

So, no disrespect intended toward our Russian friends, but I think the benefits of this "new and improved" Polyakov Direct Conversion approach stem from the unique heterodyne products of a 2:1 frequency ratio between RF input and VFO, not on the bidirectional transfer curves of two antiparallel diodes. At least that's my take on it, and I'll gladly retract this opinion if the facts warrant it in the future.

I learned a couple of other things in designing the new DC-80 receiver: Terminate the antenna preselector bandpass filter with a 51 ohm resistor, at the input of the diode mixer (see schematic). This seems to reduce AM bleedthrough and makes little difference in overall volume level (I thought the reduction from RA3AAE's 500 ohms down to 50 ohms would kill all my audio output. It doesn't. There's something to be said about designing around a stated impedance level, like 50 ohms.)

Also, I learned that the first audio transistor ought to be configured as a common-base circuit, whose input impedance is also low (close to 50 ohms). Not only does this seem to help with the rejection of AM bleedthrough, but it makes a surprising difference in the quiescent noise level of the audio amp, with the antenna disconnected! Some of the other projects on my webpages would probably be better performers if I had known this before this particular project taught it to me. I deliberately reconfigured Q2 as a common-emitter amp with the signal going into the base in the "normal" way we think of transistor amps being wired.....

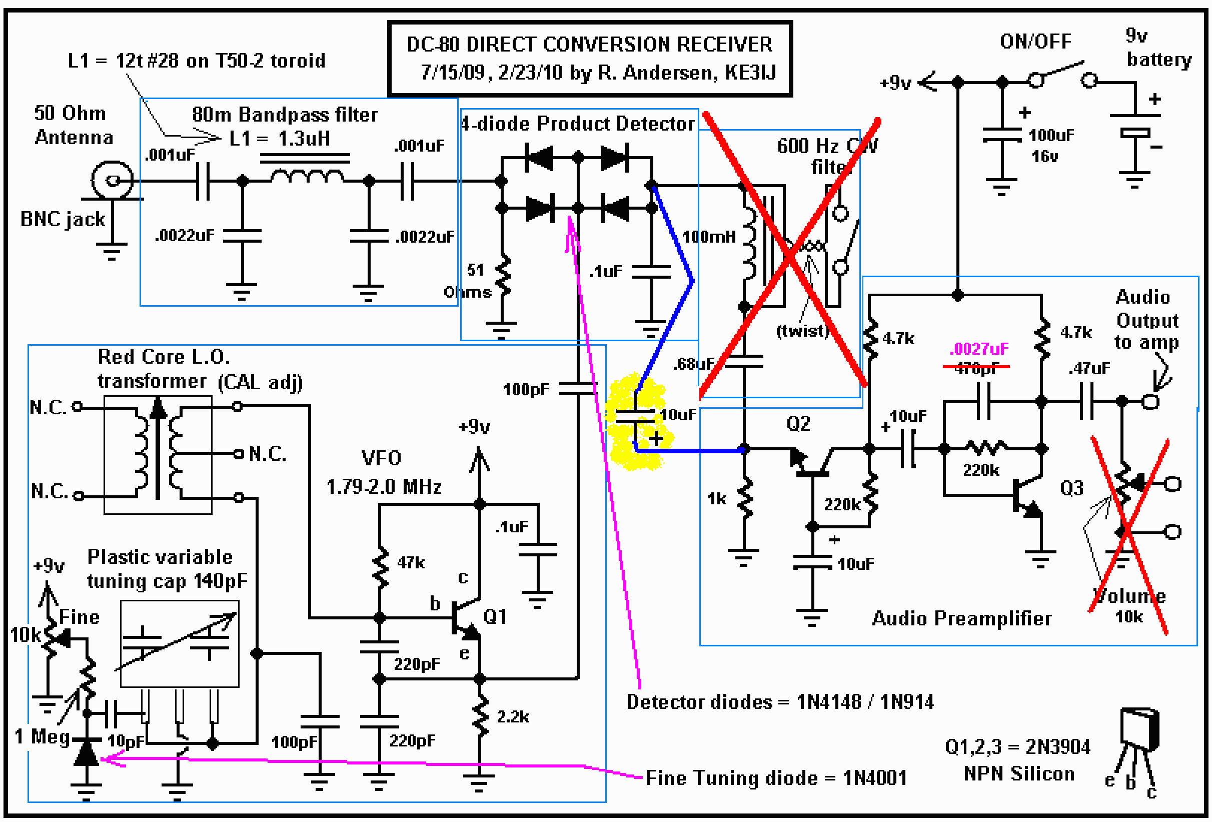
...as a common emitter amp, the receiver was quite noticeably noisy (a constant hiss) with the antenna disconnected. When I went back to the common-base setup, with audio going into the emitter, the amp quieted down to a whisper without antenna, yet was amply loud and crisp when SSB or CW signals were coming through, with antenna connected.

I'm also happy to report that there are neither microphonics, nor any common-mode hum, discernable in this receiver -- although I have not yet enclosed it in a box, which may rain on my parade, based on previous experience. The only problem I encountered was some genuine, non-raspy 60 Hz AC hum getting into the 100 millihenry inductor that I use for the CW filter. ~~I mounted it upside down so that its top was glued to the copper ground plane floor of the circuit, and I tightly twisted the short length of hookup wire coming off that inductor and connecting to the CW filter toggle switch. There was a big reduction in hum once I twisted those switch wires together. There remains a slight hum when the filter is switched to the "CW" position.~~ I eventually eliminated the inductor, .68uF cap, and CW filter switch and replaced them with a single 10uF electrolytic cap connecting detector output to audio amp input (emitter of Q2). IGNORE the CW Filter section of the schematic diagram, below.

PLEASE ALSO NOTE: Two other changes I made to the schematic below: 1) Change the 470pF ceramic cap across Q3's base resistor to a .0027uF. This compensates for the lack of 600 Hz CW filtering which I removed. 2) I removed the Volume Control pot shown in the schematic, for lack of real estate in the small box I finally ended up with. I connected the audio output cap directly to the audio output jack. A cable plugged into the jack connects to one of the infamous beige-colored Radio Shack Amplified Speakers, which is my preferred method of dealing with audio amp requirements.

Schematic Diagram of the DC-80 Receiver

Let's get into the nitty-gritty of the new Direct Conversion receiver. The schematic, below, is relatively simple, but to make things easier I have broken it up into 5 sections, outlined by the thin blue blocks superimposed over the schematic itself.



Referring to the schematic above, let's go through a description of each section:

Front End Preselector

If I can get away with avoiding large-turn coils up front, I do it. The 80-meter band front-end "preselector" filter described here was also shown as an alternate filter in my AGC-80 series of articles. It's essentially a "Pi" lowpass filter combined with series input and output capacitors, whose combination gives a sharp *bandpass* response. I designed the filter using an old version of *MicroCap* circuit analysis software which shows me a plot of the frequency response as I vary the parts values. I'm pretty sure this filter is my own invention; I haven't seen it used anywhere else. It works for me.

This configuration allows me to use fairly large caps -- .001uF and .0022uF (which are the same as saying 1000pF and 2200pF) -- along with a fairly small inductor -- 1.3 microhenrys -- which is easy to wind. Just take about 8 inches of #28 enamelled copper magnet wire (Radio Shack sells a bag of 3 sizes) and wind 10 to 12 turns on an Amidon T50-2 red-gray toroid core....which Electronix Express sells as part number 152750-2. Adjust the spacing of the turns on the coil for peak reception. Drip some melted candle wax over the windings to hold them in place, once you've squeezed or spread them for the loudest volume on an incoming signal.

The caps I use, by the way, are the green mylar caps that Electronix Express sells (I call them "chiclet" caps, because they remind me of the litte green cubes of spearmint gum that go by that name). I believe plain old ceramic caps would work, too, but I have always used the mylar "chiclets" in my designs.

The 80m filter is intended to be used with a 50 Ohm antenna impedance, and it is terminated in a 51 Ohm resistor in the radio circuit. If you want to scale the filter up or down (40m or 160m bands), you just need to calculate the capacitances and inductance from the standard formulas, and knowing the reactance values of the components, which are constant for a 50 ohm system, keeping the reactance ratios the same for all bands. The reactances are: 42 Ohms for the .001uF series caps, and 19 Ohms for the shunt caps to ground. The toroidal coil's inductive reactance is 31 Ohms.

The standard formulas are as follows:

Inductance L = Reactance XL divided by (2pi x Frequency) **L=XL/(2pi F)**

Capacitance C = 1 divided by (2pi x Frequency x Reactance Xc) **C=1/(2pi F Xc)**

So, for example, if we wanted a front-end filter for ***40 meters***, using 7.2 MHz mid-band for F,

1) the series caps at Xc = 42 Ohms would be calculated as **1/(2pi x 7.2E6 x 42)** which comes out as 5.263E-10 Farads on the calculator. Multiplying that by 1E12 converts the answer to picoFarads.... = 526pF. Since that isn't a standard value, I might try a 470pF or 560pF cap instead, and modify the turns on the coil later, if necessary.

2) For the shunt caps at Xc = 19 Ohms, the same formula gives me a capacitance of 1163pF, so I'll substitute a 1000pF = .001uF cap for that.

3) For the toroid coil, with XL = 31 Ohms, the equation would be **31/(2pi x 7.2E6)** or .000000685 Henrys, which, when multiplied by by 1E6 to convert to microHenrys, gives 0.685uH for our inductance.

But how do I know how many turns this equates to on the toroid? Well, lacking an exact formula, I can reason that, since I doubled my frequency to get from the 80 meter to the 40 meter band, and my original inductance of 1.3uH has just about been cut in half, at 0.685uH, then maybe I ought to put about half the number of turns on the toroid....I'll try 6 turns, and adjust the spacing for a peak later on when I'm testing out the receiver.

Yes, this is "designing by the seat of my pants" but it's OK; it works well enough; don't sweat it.

Notice that the coil is already less than 1uH at 40 meters. This tells me that my 'special' pi-bandpass design won't work well for any other high bands; for 20 meters I would need to change the filter design to something more conventional. But it should be OK for 160, 80, and 40.

Since my design has such easily-obtainable parts and low coil-turns, and has 50 Ohm impedance levels throughout, this also means you can cascade two of these filters in series, if you want even more out-of-band rejection. Again, simple, non-critical, and intuitive.

On another subject relating to the receiver front end:

The RA3AAE-style receiver schematic showed a transistor RF amplifier up front, before the diode mixer. I had a front-end RF amp when I first built the RA3AAE circuit, along with its 500 ohm impedances in the mixer. Bottom line, the increased gain up front invited noticeable AM bleedthrough, no matter what I tried to do to minimize it. When I remembered an ARRL publication stating that, on 80 meters at least, a well-designed DC receiver doesn't need an RF amp, I took mine out, feeding the output of my antenna preselect filter right into the diode mixer, with a 51 Ohm termination resistor to ground at that point. The result was that I was still able to receive loud signals and the AM bleedthrough was cut way down, almost to the point of disappearing, although you can still hear it occasionally when tuning to a blank spot on the dial.

4-Diode Product Detector

I've already described my experiments with the Polyakov configuration and other variations, so I'll just stick to a description of the detector stage here.

The bandpass preselect filter, just described, sees a matching termination in the 51 Ohm resistor that shunts the input of the 4DPD diodes to ground. This helps kill the "AM broadcast blanketing" that plagues simple receivers. The resistor also provides a DC path to ground between the "pumping" action of the VFO input cap, and the diodes.

The diodes, which are plain vanilla 1N4148 (=1N914) switching diodes -- nothing fancy, nor did I make any attempt to "match" them -- can be seen either as a left-hand Polyakov antiparallel pair, joined to a right-hand Polyakov pair, with the VFO injecting its signal in the middle of the two; or, one can view the arrangement as an "upper" 2-diode product detector, joined with a "lower" 2-diode product detector of opposite polarity, in parallel, with the VFO driving both their midpoint junctions simultaneously. When the polarity of the VFO signal is positive, one pair of diodes conducts. When the VFO goes negative, the

other pair conducts. Same thing as a Polyakov, but done a little differently. However you want to view this 4-diode arrangement, IT WORKS. In fact, it sounded a bit louder to me when I strapped the 2nd pair of diodes into the circuit, as if it were more efficient.

The VFO signal is coupled into the center of the detector through a 100pF ceramic cap.

The output is taken off the right side of the diode array, with a 0.1uF cap to ground, which bypasses the RF output of the mixer and leaves only our baseband audio. I tried putting another 51 Ohm resistor in series with that cap to ground, in an attempt to imitate one of the "diplexer" circuits I found online in a "DC 'Popcorn' Receiver" schematic, but there was noticeable AM bleedthrough(!) When I removed the resistor and put the bypass cap straight to ground, the AM stuff disappeared. Go figure.

For those of you whose 'common sense' tells you that 0.1uF is much too large a cap to use -- that it will make the audio sound too mellow... -- Surprise! -- it's not like that when you're living in a 50 Ohm world! That 'common sense' only works when your "background" impedance is up around 1K to 10K. The signal is still quite "tinny" at the output of the 4DPD, and needs some more mellow-out filtering later on, in the audio amp. (I bring this up because I once came across a pair of pundits critiquing one of my radio circuits on some blog somewhere. They applied the standard "f=1/(2piRC)" roll-off formula to my component values and concluded that my audio must be as mellow as jello because my bypass cap appears to be way too big. Not in a low-impedance circuit, though. Hasn't it ever occurred to you to wonder why the coupling cap feeding the 8-Ohm speaker in an audio amp has to be way up there around 470uF or more? You need to dump more charge through a smaller resistance in order to get the same power.)

But I digress.

"Subharmonic" VFO

We leave the mixer/detector output for now and travel down to the VFO.

As any good Ham knows, the VFO can make or break a receiver. So let me say right here: *I wanted a quick and dirty, functional VFO; simple and cheap.* So I used only a single stage, with no buffer. I basically took a Clapp Oscillator design and used the perfect "coil" for that oscillator, at 1750 - 2000 KHz..... one of those little oscillator cans with the red screwdriver-adjustable cores, which tunes the Local Oscillator (L.O.) in an AM broadcast radio. Voila! No coils to wind with dozens of turns at 160 meters. Because -- remember -- we are running the VFO *Polyakov*-style, at 1/2 the RF input frequency.

To make things simple for me and for you, I also borrowed the variable tuning capacitor from cheap transistor AM radio design -- one of those little plastic-cased tuning caps with the 3 leads coming out the side. Unlike the metal-plate 365pF variables of the days of yore, these plastic "polycaps" have a total capacitance of around 140 - 170 pF for the RF section, 60pF or so for the L.O. section [intended for a superhet receiver]. I soldered the two cap sections in parallel (the outer leads) while grounding their bottoms through the center lead. Then I also have a 100pF cap in parallel with the whole thing, and series connected 220pF's as the feedback caps in the base-emitter circuit of the 2N3904 transistor, Q1. These values were obtained by experiment and could be improved upon. In fact, the whole VFO was hastily designed and could be improved upon. It's a bit drifty in frequency, but it works! Without taking any "dBm" measurements, it provided a very adequate injection level from the first moment I turned the radio on, as evidenced by the crisp, loud signals I'm able to hear, and by the relative lack of "spurs", "tweets", and unwanted intermodulation products.

So there! If you don't like it, make it better! I'm admitting that I scrimped where I probably should have been a lot more careful.

2/23/2010 Revision: Added a Fine Tune "Clarify" Control

The right-most knob on the front panel of the encased DC-80, which you'll find farther down the page, is the Fine Tune pot. It operates like the Bandspread tuner in old shortwave radios, and like the "Clarifier" knob on some old CBs. In a nutshell, the 140 pF plastic tuning cap tunes the whole 500 KHz -- 3.5 to 4.0 Mhz -- of the 80 meter band. With no gear reduction, one half-twist of the knob covers the whole band in one fell swoop, and the tuning rate is too fast for comfortable operation. I've added a parallel "fine tune" which is a 10k potentiometer controlling a reverse-biased rectifier diode, used as a varactor tuning diode. The 0-9v at its wiper is isolated from the VFO through a 1 Megohm resistor, and lightly coupled to the top of the plastic Main Tuning cap via a 10pF ceramic cap.

To operate, start with the Fine Tune knob set in the center of its range. Tune in a station with the Main Tuning cap, and tune for a 'zero-beat' with CW signals, or, tune for a deep growl on SSB voice signals. Now, turn the Fine Tune left or right until the "growling" SSB voice "clarifies" to a normal pitch. If tuning CW, tune to the desired beat note.

Since one of the distinctive traits of a simple Direct Conversion receiver (or Regenerative receiver, for that matter) is that it lacks *single signal* capability (i.e., you are able to hear the signal on **both** sides of "zero-beat"), you will be able to tune SSB voice signals either "correctly" or "backwards"--- if you're on the "left" side of zero-beat, the voices will sound garbled and impossible to understand [because of audio spectrum inversion of the sidebands]. Turn the Fine Tuning control clockwise through zero-beat, and you will end up on the "right" side and will be able to hear intelligible speech, although it will vary from a deep/low sound to a high "chipmunk" sound; somewhere in the middle of that range you will hear a normal-sounding voice. The Fine Tune pot helps you clarify that voice with a slower tuning rate.

~~Switchable CW Filter~~

~~Back up to the output of the mixer/detector:~~

~~I use one of the small, cylindrical blue inductors from Electronix Express in a series bandpass filter, as my very simple CW filter [the inductor also blocks any RF that the 0.1uF bypass cap may have missed]. The choke (as they call it) has a value of 100 milliHenrys, with a DC resistance of around 100 Ohms (they must have a lot of turns of very fine wire inside). That 100 Ohms knocks the Q down, making a rather broad filter, but it's adequate for such a simple filter. The other component making up this filter is a mylar cap whose value I have listed on the schematic as 0.68uF; this value, along with the 100mH choke, gives a resonant peak at around 600 Hz. If you prefer a 750 Hz peak as many QRPers do, change the cap to 0.47uF.~~

~~A toggle switch is wired across the 100 mH choke. When the switch contacts are OPEN, the choke is in circuit and you're in 600 HZ "CW" filtering position. When the switch is CLOSED, the choke is short-circuited and the audio signal travels straight from the detector output to the 0.68uF cap, which doubles as a blocking/coupling cap for the input of the audio amp, Q2. With the choke out of circuit, the audio is unfiltered and quite "bright" [tinny-sounding], to be mellowed out just slightly in the audio preamp circuit, described in the next section.~~

~~One "gotcha" that I experienced with the 100mH choke inductor was that it picked up a healthy amount of 60-cycle AC hum from the soldering iron. I mounted it upside-down, gluing it to the copper ground plane on which I built the prototype (see picture near the end of article). The hum got worse when I wired the CW Filter switch across its leads. I then twisted the two switch wires together, which killed most (not all) of the hum. Your mileage may vary, so keep the physical distance short between the choke and the panel-mounted CW Filter switch, and twist the two wires leading to the switch, tightly, down their length.~~

Quiet Audio Preamp

Well, a lot quieter than some I've built, anyway.

As usual, I built this receiver without an audio power amp. Instead, I route the output to a Radio Shack Amplified Speaker (steadily rising in price; now about $14.99 I think; I'd like to believe that all my articles extolling the virtues of this little amp has caused business to boom for Tandy Corp.; at any rate, I remember these little beige boxes costing around $11.99 back when I started this website) and lately I've been plugging a computer speaker into the aux output of the Radio Shack amp for better sound.

As I've described elsewhere in this article, I discovered that this receiver's quiescent noise, heard when there is no antenna connected, was drastically reduced when I compared Q2 wired in a common-base configuration, with Q2 wired in a common-emitter configuration. I'm not sure of the correct explanation, other than to say that in the common-base circuit, the input impedance is low, giving a good match to the 50 ohm level designed into the receiver front end.

~~The same 0.68uF cap [or 0.47uF alternate] that serves as the capacitive element in the L-C CW Filter, also serves to couple the weak audio from the detector into the emitter circuit of Q2, a 2N3904 like I always use.~~ I now use a 10uF electrolytic here.

The cap serves to block DC at the same time; there is approximately 1 volt DC at the top of the 1K emitter resistor, and we don't want that bias to affect the diodes in our mixer. So we "cork it up" with that cap, which serves to "couple" AC (audio), while "blocking" DC (Q2's emitter voltage). [I used to tell my electronics students that a cap passing AC while simultaneously blocking DC is like waving at someone through a glass window: They can see an image and movement (change; AC) but if you try to blow a stream of air at them, the glass blocks the flow (flow; DC). I'm sure that that explanation caused less brain damage than a friend of mine did when he used to play mind games with his young boy by shaking his head up and down when he meant "No", and side to side when he meant "Yes". The kid is probably doing prison time by now.]

A 220k resistor supplies positive current to Q2's base, while a 10uF electrolytic cap bypasses any audio on the base, to ground. Doing this forces the collector to output an amplified version of the audio variations coming in at the emitter. The amplified audio is picked off Q2's collector and 4.7k collector load resistor, coupled to the next stage through another 10uF electrolytic, and sent into the base of Q3 for further audio amplification. Q3 is grounded at its emitter (a common-emitter configuration) while the base is supplied with DC bias through another 220k resistor. Both stages connect their base resistor to the collector; this is known as "collector biasing" and is a form of negative feedback that automatically sets the transistors' bias at the optimum operating point in their bias curves.

Notice that there's a ~~470pF~~ .0027uF cap across Q3's base bias resistor. This is a bit of "mellowing" for the tinny-sounding audio I mentioned earlier; a simple low-pass filter to take some of the edge off the highs... so that the piercing whistle of W1AW's code practice signal doesn't drive you batty even when tuned 8 KHz away!

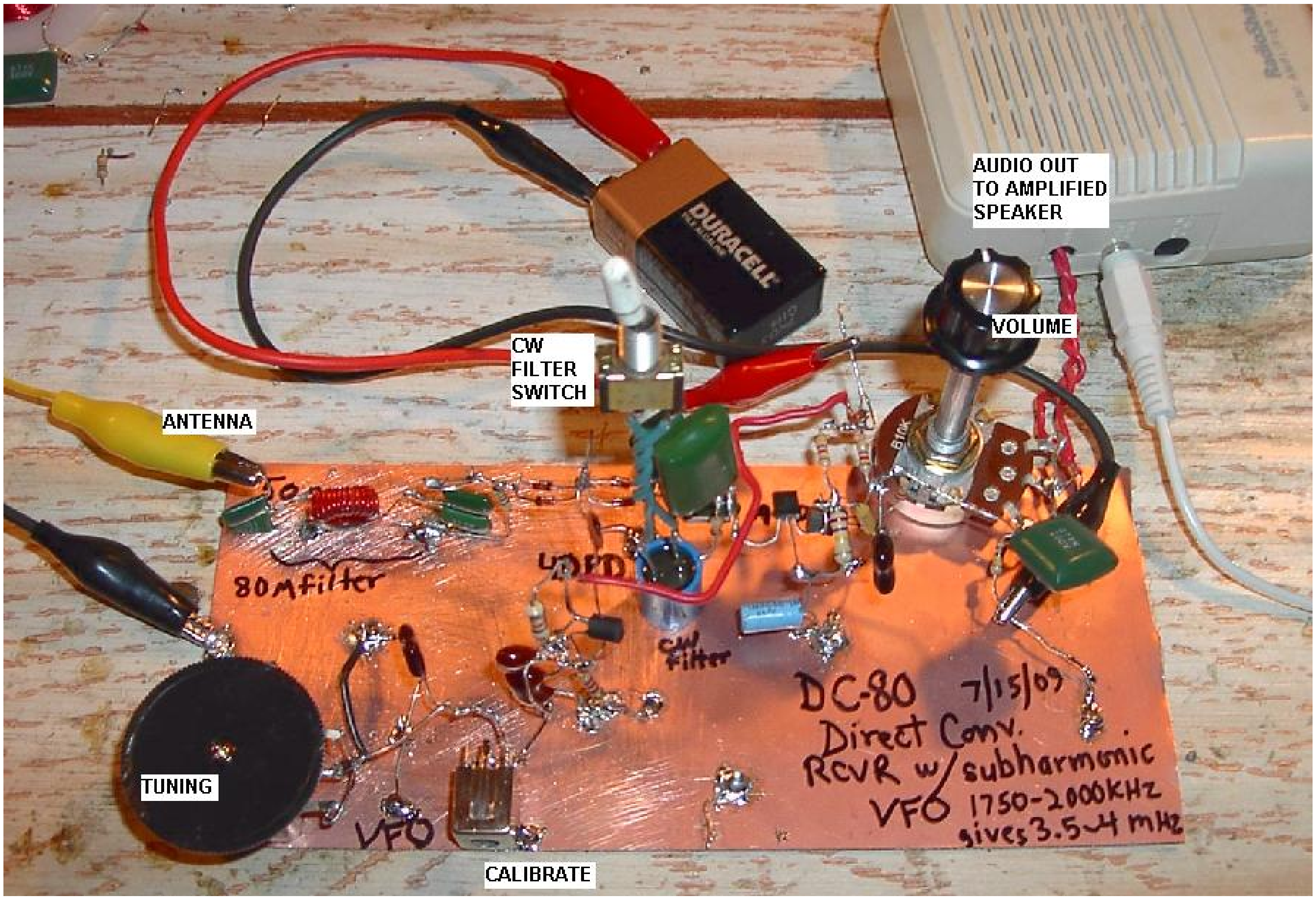
But note that when the CW Filter switch is "off" -- shorted, actually -- the only filtering that the audio sees is that of the 0.1uF cap at the detector output, and this ~~470pF~~ .0027uF cap across Q3's base bias resistor. So the guys on SSB and AM phone sound sharp and right there in the room with you... and static crashes are that much more noticeable, ~~whereas in the CW position, static is greatly reduced by the action of the 600 Hz bandpass filter, and the extremely high-pitched CW tones are mostly filtered out.~~

~~At the collector of Q3 we couple the audio out to a 10K potentiometer (Volume Control), which is a variable resistance voltage divider whose wiper connects to the audio output jack. High-impedance crystal or magnetic headphones may be connected here, although I prefer to connect my amplified speaker here instead. You may ask why I put in a volume control, if the Radio Shack amp already has one at its input? The reason is that there is a lot of amplification (audio gain) from Q2/Q3, and the Radio Shack amp was actually being overloaded, during the peak of the SSB yakking hours in the evening, even with the amp's volume control turned almost all the way down. This made me happy, because as a seat-of-my-pants designer, I knew that enough audio to overload the Radio Shack amp was certainly enough to drive most headphones to at least adequate volume. (Since I don't have a pair of decent 2000 ohm headphones, I have to make educated guesses about how the receiver will sound to someone who does have them ;-)~~ I left the Volume Control out of the revised version because it would not fit in the

small enclosure from Mouser (although they do sell larger versions of the box). I made the decision to simply send the strongly-amplified audio to the rear audio jack, and to let the volume control on the Radio Shack Amplified Speaker suffice as my gain control. If you decide to build the DC-80 in a bigger box, you may decide to put it back into the circuit.

A Picture of the Prototype

It's ugly! -- it's scary! -- it's coming to a theater near you -- it's not in an enclosure yet! -- but here it is. I've marked the major components with labels or with black magic marker on the copper-clad board. If you build it and it starts giving you trouble in an enclosed box like some of my earlier DC receivers did, you have the right to box my ears and pommel me. But I wanted to get the new design up as soon as I could. If you look closely at the picture of my prototype, you can see that there's really not much to it, that it should work as well as it does. This 1/2 frequency VFO thing really seems to have breathed new life into the lowly Direct Conversion Receiver. Build one of your own, and if you don't think it performs, look at it as a learning experience.



2/23/2010 UPDATE: The DC-80 in an Enclosure

Mouser Electronics to the rescue! I found a cute little "bone-white" plastic box in the Mouser catalog, part number 616-79160-510-039, which is a small 4" x 6" x 1.5" high plastic box with top and bottom pieces, plus removable front and rear plastic panels that fit in grooves between top and bottom sections. The top and bottom are held together with long screws that go in through the bottom. The enclosure comes with 4 press-on adhesive rubber feet. Only $7.70 + shipping at the time of this update in February 2010.

Here are some photos of the DC-80, rebuilt on a small copper ground plane and mounted in the Mouser box:


DURACELL


DURACELL

PARTIAL Parts List

I'm not gonna give you part numbers for every resistor and cap in the circuit. The resistors are 5%, 1/4 watt types and most of the caps are the green mylars. The big cylindrical caps with polarity markings are electrolytics and should have a DC working voltage over 10v. The VFO injection cap happens to be a 100pF ceramic. You can go to the [Electronix Express](#) website and browse their online catalog for yourself. But the 'unique' or unusual parts are listed here, for your convenience and abatement of confusion.

I've decided to give [Electronix Express](#) a big plug in this article, since I've dealt with them before and found that they almost always have the kinds of components I need for QRP radio projects -- like the inductors and variable capacitors. Sometimes a few of their parts are back-ordered and take a while to arrive, but for the most part, my orders arrive at my door within a week. (I used to teach Electronics at ITT-Tech, and Electronix Express -- under their alternate name, RSR Electronics -- was our source for electronic parts and kits used in our Lab courses.)

<u>Front End</u>

Antenna connector - BNC female, panel mount. You'll notice in the picture that my prototype doesn't use one, but uses alligator clips instead. Well, when I put it in a box, I'll use a BNC connector, OK?

L1 = 1.3uH coil. Wind 12 turns #28 magnet wire on a T50-2 toroid core (Electronix Express # 152750-2) and adjust turns spacing for loudest signals in the middle of the band (windings cover about 1/3 of the core).

Caps = green mylar types at [Electronix Express](#)

<u>Detector</u>

Diodes = 1N4148 / 1N914 silicon switching diode

<u>VFO</u>

Q1 is 2N3904 NPN silicon, like I use in most of my projects.

Transformer is the red core Local Oscillator "can" that is used in most transistor radios. Electronix Express # 16IFR, or Mouser/Xicon 42IF100-RC.

CALIBRATION: Set a nearby receiver to 2.000 MHz, and, with the DC-80's tuning cap turned fully clockwise (top of band; least capacitance), use a screwdriver to adjust the red core until a loud "whoop!" is heard in the 2 MHz receiver. This sets the top of your DC-80 at 4.000 MHz (top of the 75M band), with the VFO running at half the RF input frequency. Re-calibrate if the bottom of the 80m CW band falls out of range, if needed (i.e., the receiver may not tune the entire 3.5 - 4 MHz band, depending on parts tolerances, etc.)

Tuning capacitor is Electronix Express p/n 14VCRF10-280P, the typical AM transistor radio plastic tuning cap with 3 leads. In this receiver we connect the two end leads together (connects to L.O. transformer) while grounding the middle lead.

~~CW Filter~~

~~Inductor is a 100 millihenry cylindrical choke, Electronix Express # 150100M.~~

~~CW Filter switch is SPST toggle or slide switch, whichever floats your boat.~~

Audio Preamp

Q2 & Q3 are 2N3904 NPN silicons, like I use in most of my projects.

Volume Control = 10k Ohm potentiometer with ON/OFF switch, Electronix Express # 18PMS10K

Power & Miscellaneous

9 volt battery

Battery clip

100uF, 16vDC electrolytic capacitor (bypasses entire receiver, preventing motorboating oscillation)

Final Comments

~~The receiver needs a "Fine Tuning" control. This could be a small-value variable cap strapped across the Main Tuning cap in parallel with it.~~ The single, miniature plastic variable cap knob has no gear reduction or vernier action (obviously) and it's hard to properly "clarify" SSB voice signals. There's also some body capacitance effect with the circuit unenclosed. Tuning is pulled off frequency when you've zeroed in on a station and then taken your hand away.
Added a Fine Tune "Clarify" Pot; see above.

There is still some discernable AM bleedthrough, but not much at all. It's much easier to mentally screen it out with this receiver, compared to, say, a *Pixie* or other simple Direct Conversion receiver which lacks a double-balanced diode ring mixer up front.

The receiver could also use some form of AGC, like I use in the AGC-80 series. But, as I said, this prototype was meant to prove the 1/2 VFO frequency concept of the Polyakov-style mixers; these other comments are refinements for another day.

If you decide to put one of these simple receivers together, I'd like to know how yours works out. Email me at rick@ke3ij.com

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Back

The RixPix

My Version of the Pixie Transceiver

3/18/2005 by Rick Andersen, KE3IJ

The Pixie, Pixie-II, etc., are a very popular group of QRP tranceivers among Hams who are interested in building "minimalist" rigs. The original Pixie design, which can be found at many sites on the Web, consisted of a crystal oscillator followed by a one stage, milliwatt power amp, with a Pi output filter feeding a 50 ohm antenna. When the key was not being pressed, the emitter current to that "power amp" (a 2N3904 or 2N2222 transistor) was limited to a small value by a 10K ohm emitter resistor; in this "receive mode" the power amp base-emitter junction was being used as a diode detector while the crystal oscillator was beating with signals coming *into* the antenna and Pi filter-- a rudimentary Product Detector.

The RF was filtered out of the audio beat note by a small-value capacitor around that same emitter resistor, and the emitter served as a pick-off point for the audio which was now amplified by an LM386 audio amp IC, configured for its high-gain mode. The output was either an earphone or a tiny speaker. There was no audio filtering (other than the emitter resistor's parallel cap) so the CW (Morse Code) signals heard were "hi-fi" but it was impossible to listen to any one signal individually-- you had to train your ear to pick one pitch out of the jumble (part of the price one pays for minimalist circuitry).

When the key was pressed down, the emitter was grounded directly, which served the dual purpose of 1) greatly increasing the emitter current, so that the "power amp" was now operating as such; this was the "transmit mode". And, 2) the audio amp's input was shorted to ground, preventing the transmit signal from overloading the audio stage.

Compared to the usual transceiver circuits out there, this little gem had practically *no* fancy circuit tricks normally needed to switch over from transmit to receive, except for a diode-resistor pair that interrupted power to the LM386 audio amp in the transmit position. A very clever design that provided basic transmit/receive functionality in an extremely simple circuit that, some would say, "shouldn't even work".

Many QRPers and clubs have made the Pixie available as a kit. Many Hams have built it. I built one (from scratch, using "Ugly Construction" over copper-clad board as a ground plane) and actually made a couple of contacts using a flea-power 2N3904 transistor in the output stage. That was neat... but not always easy! I didn't measure my power out, but I'd bet it was well below 100 milliWatts.

So these Pixies *do* work. But they have their drawbacks, as you would expect from any rig this simple.

30 Meters

My first Pixie clone was built for 30 Meters (10.108 MHz crystal).

Immediately I ran into these problems:

1) AM (SW) broadcast interference/intermod/overload: There are a lot of strong shortwave broadcast stations around 9 MHz, and more around 11 MHz; when your input filter is a Pi-type (a low pass filter with reactances around 50 ohms), there is next to no selectivity at the front-end (the receiver is not able to pass just the narrow band you're interested in, while rejecting the surrounding interference several KHz away. Instead, it passes *everything* below the Pi network's cutoff frequency. Of course, only the frequencies adjacent to the VXO get converted down to baseband; yet, a broad front end invites AM overload problems).

I tried changing the Pi filter to one of several variations on a parallel LC tank circuit, tapped down for impedance matching to the 50 ohm antenna, but invariably I found that when the filter's "Q" was high enough (bandwidth was narrow enough) to reject the surrounding broadcast stations, the circuit would become unstable (crystal would "chirp" when keyed, or tank would go into self-oscillation).

2) The end-fed long-wire antenna (with antenna tuner) that I originally used, seemed very prone to picking up noise and *common mode hum*, which is that annoying, raspy hum that Direct Conversion receivers are particularly bad at rejecting (actually, they *generate* it, indirectly, when harmonics of the receiver's oscillator ride into the DC power supply rectifiers and re-enter the receiver through the power buss). Even when I used a 9v battery and discarded the well-regulated DC supply, I still experienced a similar hum when the antenna tuner was tuned to its resonant point.

3) Later I changed my station's antenna to a full-wave horizontal loop, with an antenna tuner, and noticed some improvement with the common mode hum problem; this seemed to be in line with advice from other QRPers that one ought to use a tuned, resonant antenna (like a dipole), or at least a balanced antenna, rather than an end-fed one which is unbalanced electrically. Changing back to a Pi filter, now that I was using a loop antenna and tuner, seemed to eliminate most of this hum problem.

But overall, I still didn't like the tiny rig's performance.

Changing to 80 Meters

More recently, a fellow Ham got bitten by the Pixie bug, and bought a kit from the Internet. Our experiments focused on 80 meters this time, using a 3.579 MHz colorburst crystal. This worked much better, I found, because there aren't many megawatt European shortwave stations operating below 5 MHz. On 80 meters, you can get away with a front-end whose selectivity is as "broad as a barn door", as they say. I also tried a 7.040 MHz crystal (40 meters) and, while it certainly *worked*, I found that the old AM broadcast blanketing was happening again. Ditto with 14.060 MHz (20 meters), where I thought I would not have that problem. So I switched back to the 80 meter colorburst crystal, and the only real hassle I experienced was when ***W1AW*** would come on the air with its nightly code practice... although a couple of KHz away from my crystal frequency, the signal blasts into my South Central Pennsylvania QTH with a strength of around +30 dB over S9 some nights, and the high pitch is piercing enough to make me want to sail the ol' Pixie right out the basement window!

So I decided that I couldn't live with the bare-bones Pixie... time to modify and enhance her!

KD1JV's "AP-80" Alternative Pixie

I know some of my readers will wince at the suggestion-- why would I want to "complexify" the Pixie when it was *meant* to be a "minimalist" rig? And, If you're gonna double or triple the parts count, why not just build a "real" transceiver, or a "real receiver [a Superhet]", etc., etc.

Well, just when I started feeling guilty and un-American about all this, I ran across KD1JV's web page, and read about his majorly-modified Pixie, the AP80. While I certainly admire what he has done, he also makes a few criticisms of the Pixie that I have to take exception to:

"The transmitter was unstable" -- Not my experience, unless I tried a parallel tank in place of the output Pi network.

"Couldn't hear anything but exceptionally strong signals" because the detector *"has large conversion losses since it's not configured in a very optimum way."* -- Nope, mine is quite sensitive, maybe because of all the audio gain and filtering I put in.... see below.

"PA got very hot putting out what little power it did." -- No, I was getting S6-S7 reports from my buddy over 30 miles away (lots of Pennsylvania's rolling hills and small mountains between us) using just a 2N3904 running

off a 9 volt battery! And it stayed perfectly cool.

CAUTION--I did find that, when I used a 2N3053 for the output transistor, it got hot ***if there was any reflected power showing on the SWR/Power Meter****, so be careful to tune your antenna system to resonance and proper Z-match with a tuner. Once tuned to maximize forward power and eliminate all noticeable reflected power, the transistor stayed relatively cool to slightly warm, with no heat sinking. I recommend you use a small heat sink--one with fins that slips down over the metal body of the 2N3053 transistor.*

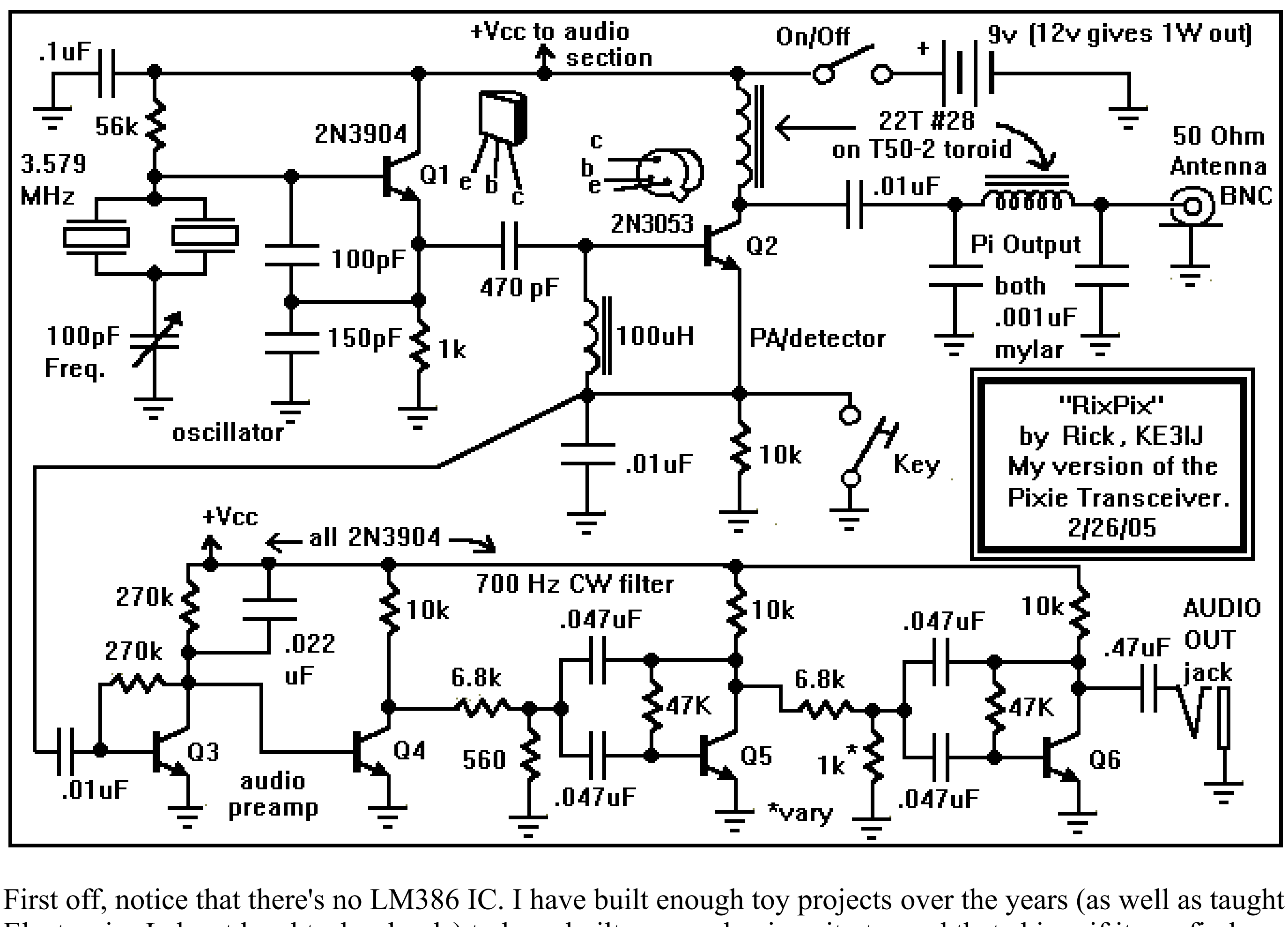
Continuing,

"All the receiver gain is supplied by the LM386 audio amp, which is strapped at full throttle. What we end up with is a high level of background noise." -- I use 2N3904 NPN transistors throughout, followed by an external Radio Shack amplified speaker. Very pleased with the results.

KD1JV presents a fairly complex makeover of the Pixie, and, don't get me wrong, I'm not at all criticizing his work-- this is what Ham radio is all about, and we need more innovators in our ranks!-- but when I saw how big his circuit got after his modifications were implemented, I thought "Gee, I think I can build me a Pixie with a lot less complexity, but that still represents an improvement over the original." So I got over my guilt trip and wasted some 2N3904's and circuit board space in coming up with my own mutant Pixie-style transceiver.

My version of the Pixie

Here's the schematic for my version, which I named the **"RixPix"**, cuz it's, well, you know-- "Rick's Pixie"! At least it distinguishes my modified circuit from the others, should anyone out there actually want to try building it.



First off, notice that there's no LM386 IC. I have built enough toy projects over the years (as well as taught Electronics Labs at local tech schools) to have built up a real animosity toward that chip... if it can find a way to

motorboat or squeal, it will. All "band-aids" notwithstanding, like the .1uF cap and 10 ohm resistor the applications notes recommend you hang off the output pin to ground. IF THE DAMN THING IS SO PRONE TO OSCILLATE WITHOUT THAT BANDAID, WHY DIDN'T THEY PUT IT INSIDE THE CHIP ALREADY!? Deep breath.

So call me an old fart, but I like 2N3904 bread and butter transistors. And I use them everywhere I can.

I'm also a fan of Radio Shack's little beige Amplified Speaker ($11.95), which I tack on the output of most of my radio projects. One of the few good things they still sell. And before some wise-acre points out that there's an LM386 inside that Radio Shack amp, all I can say is, If they were able to tame that bronco, more power to 'em. I'd rather not be bothered with pulling my hair out trying to figure out the optimum parts layout in every project-- just so the 386 doesn't squeal every time I turn the thing on. Besides, the little beige plastic case gives the 2" speaker just enough resonance to sound like it has some "body" and not like a piece of tinfoil.

Now let's back up and start with the crystal oscillator.

I had a spare 100 pF variable cap; that got mounted in the front panel of my L-shaped copper-clad board-chassis. With 100 pF, and a single crystal, I find that I can get a frequency swing of about 1 KHz, maybe a little less, from a colorburst crystal. The frequency goes up to about 3.5805 KHz when the cap plates are totally unmeshed; 3.5795 KHz when fully meshed.

Based on a trick I saw somewhere, I paralleled another crystal of the same frequency across the original; I was delighted to find that I can now "rubber" the VXO (Variable Crystal Oscillator) almost double the frequency range as before-- about 1.75-1.8 KHz in the 80 meter band. I imagine one could get 2 or more KHz at 40 meters and above, but I haven't tried it yet. (Yes, I did try putting a *third* crystal in parallel with the other two; no real improvement, so I stuck with just two.)

You will notice that I don't have any provision for **RIT** (the ability to automatically offset my receive frequency 600 to 800 Hz from my transmit frequency so that I'll be a little bit away from zero-beat with the other Ham with whom I'm having a QSO-- so I'll actually *hear* him!). I tried adding a transistor switch and capacitor (as many have done) but don't like how the frequency offset changes so drastically from one end of the VXO tuning to the other. Still working on this... will probably just throw in a toggle switch that either puts the 100 pF variable in circuit or shorts the bottom of the crystal directly to ground. I'll label the switch "Tx/Rx" or "XMT/RCV". Or if I'm particularly lazy that day, "T/R".

The feedback caps in the VXO are 100 and 150 pF; no special reason except they're the values I happened to have (the original used 100pF for both).

In the output stage (Q2), you may have noticed that I don't have any base bias (pullup) resistor at all, even though the original Pixie had a 33K or similar. I found, through repeated experimentation, that it makes absolutely no difference whether the resistor is there or not. So I opted to leave it out, assuring me that the drive from the oscillator must be high enough to be operating the second transistor in Class-C mode, which should keep the transistor the coolest anyhow.

I found that the output power could be increased, to a point, by increasing the value of the coupling cap between Q1 and Q2 -- mine started showing some instability at .001uF (1000pF) so I went back down a notch and left the value at 470 pF.

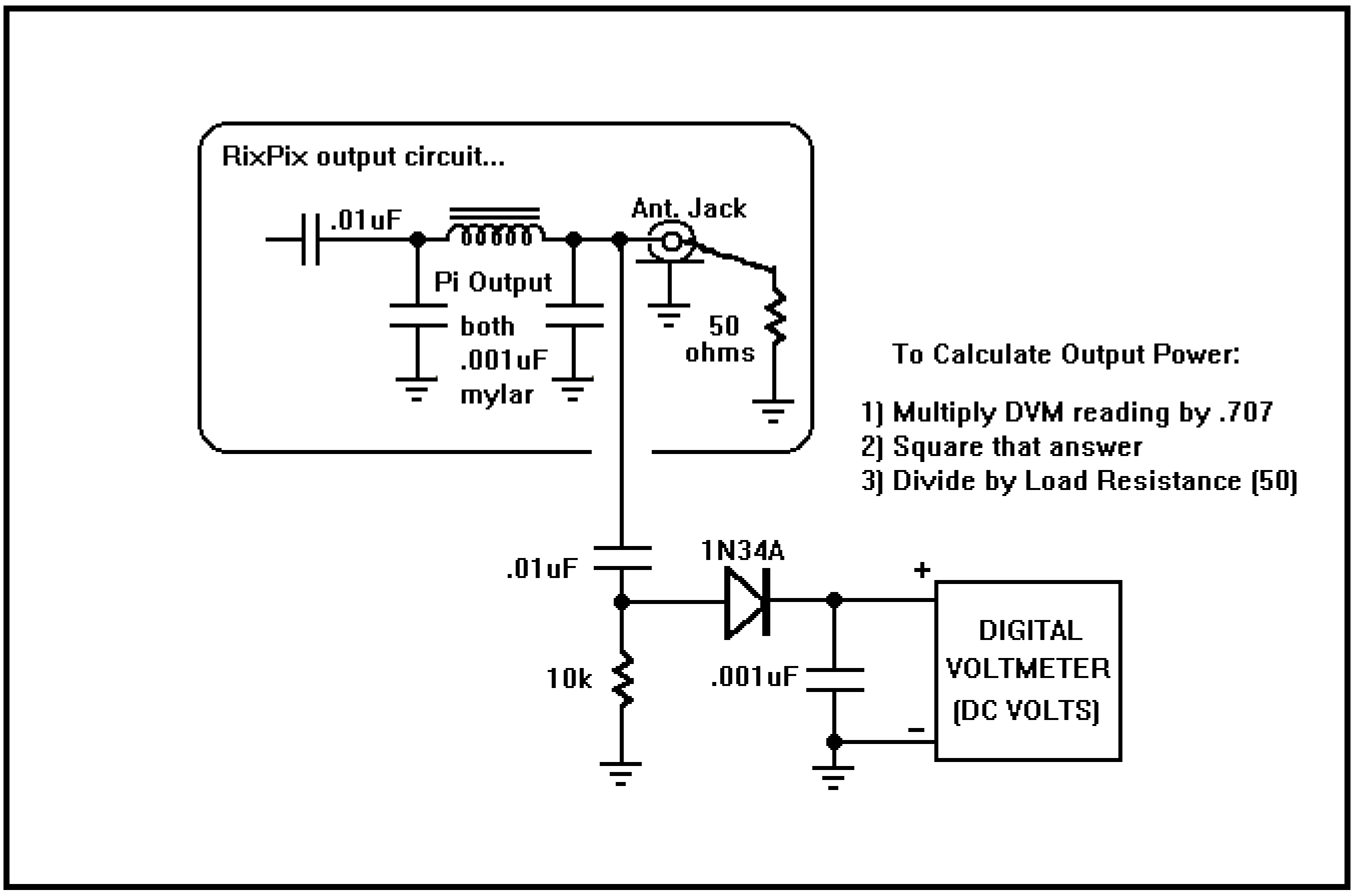
Again, the original Pixie had a 22uH choke in the collector of the power amp Q2. I surmised that the original designer must have chosen that value because it ought to be at least 10 times the value of the inductor in the Pi network. The Pi network L=2.2uH (for 80 meters). I determined that any available value of inductance should work as Q2's collector choke, if it was 22uH or greater, so I originally had a 1 millihenry inductor in its place. Cuz I had one.

Later, I discovered through computer modelling that, if that collector choke were reduced to match the inductor in the Pi filter, a nice resonant peak occured which significantly boosted the output power... up to 1 Watt with a 2N3053 output transistor and a 12 volt DC power supply (rather than the usual 9 volt battery). By nature a Pi filter is a lowpass cutoff filter; here we give it an additional resonant peak just before cutoff, which increases the output power.

My Pixie has had a 2N3904, 2N2222A, and a larger 2N3053 as its output power amplifier. They all work. I finally left the 2N3053 in as my preferred choice.

So the modifications mentioned above enabled me to get more power out than the design of the original Pixie allows for.

Though I don't have an accurate QRP wattmeter, I did the next best thing: I hung a .01uf cap off the output antenna jack, a 10k resistor to ground on the other side of the cap, a 1N34A germanium diode (anode toward antenna; cathode [stripe] toward voltmeter) also off the cap and top of the 10k, a .001uF cap to ground after the diode's cathode, and a DIGITAL voltmeter across that .001uF cap. With the voltmeter set to the 20 VDC range, I measured about 10 VDC across a 50 ohm "dummy load" when the Pixie's inductors were peaked. [See schematic below:]



The calculations are as follows:

First, the DVM, with its 10 Megohm input resistance, draws almost no current through the germanium diode; therefore, the voltage drop across it is negligible. So I take the 10v reading at face value.

This voltage is PEAK. To calculate power from voltage and resistance, I need to convert the peak voltage to RMS form, which is done by multiplying the 10vpk by .707, giving 7.07vrms.

Now I use the formula, P=V^2/R.... 7.07 squared, divided by the 50 ohm load.

The answer is .999 Watts (999 milliWatts)-- close enough to be called "1 Watt" to me!

In QSOs between my Ham buddy and me, he has been giving me consistent S5-S7 reports, early in the evening on 80 meters, with about 30 miles or so between us, with mountains in-between. He uses a dipole and I use a horizontal loop, so it's debatable whether we're communicating with ground waves or warming the clouds with straight up-and-down, very short "skip". [These experiments were performed in late March 2005.]

[3/26/05 UPDATE: My buddy took his Pixie to Pittsburgh (western end of Pennsylvania) while visiting relatives for Easter. Breaking all the rules about using "balanced antennas", etc., he used a slingshot to get a piece of ***half-wave*** *wire (130 feet long) into a very tall tree, and, using only a 9 volt battery and a homemade antenna tuner, he worked me (near Harrisburg, south-central Pennsylvania) using that end-fed half-wave antenna, and no ground to speak of. The QSO took place (with simultaneous telephone call, for backup) around 8 PM on 3.579 MHz. His power must have been only hundreds of milliwatts; my Pixie put out about a Watt into my horizontal loop antenna through a Heathkit tuner. We could not carry on a full QSO-- our weak signals were fading in and out with the band that night-- but we were able to copy about half of the characters sent. Like kids with new toys, he and I continue to be amazed that we can communicate with these ultra-simple transceivers putting out a Watt or less!]*

[4/2/05 UPDATE: Tonight I worked a station in Connecticut with my 1 Watt RixPix, on 3710 KHz. The CT. station gave me an RST of 599. Not to be outdone, my local friend (mentioned above) worked Oklahoma on 30 meters; his kit-built Pixie puts out something like 250 mW or so. We're both convinced that these little buggers work just fine!]

The theoretical 50-ohm calculations for the Pi output filter are 2.22uH for L and 890 pF for the two caps. I used 1000pF (.001uf) mylar caps and wound about 22 turns of #26 or 28 magnet wire on an Amidon T50-2 red-gray toroid, adjusting the spacing on the turns a little for maximum output of the transmitter into a 50 ohm dummy load. (Do the same with the other toroid that I have used in place of the Q2 collector choke used in the original Pixie.) The point: Use the nearest parts values you can, and don't sweat it with trying to be exact. Just adjust the spacing of the turns on the coils for highest power into a 50 ohm load.

Now for the audio section of the receiver circuit.

I like 2N3904's, I like grounding the emitter and using collector feedback bias in my preamp stages, but I hate putting blocking (coupling) caps in every stage. So, after the initial blocking cap, I use DC coupling, which then necessitates using a rather large 270K resistor in the collector of Q3, since that resistor doubles as Q4's base bias resistor. The .022uF cap across the 270K is a lowpass filter that mellows the audio and gets rid of any vestige of RF carrier missed by the cap across Q2's emitter resistor. (By the way, the .01uF for the initial blocking cap may seem too small for a transistor amp, but I verified by experiment that anything larger (such as the usual 4.7-10uF electrolytic) is totally unnecessary here... perhaps because the big resistors limit the current and cause the input impedance of this stage to look larger than usual.)

Q5 and Q6 are my pride and joy. Each one is a transistor version of the textbook op amp circuit known as the *Multiple Feedback Bandpass Filter*, with a center frequency of about 750 Hz (I aimed for 800 but with practical parts values, I got 750. What's 50 Hz among friends?). I used two of them in series or *cascade* because I wanted relatively steep rejection of CW tones outside the passband, with as little "ringing" as possible... See, I stubbornly tried to "cheat", for a long time, by trying to squeeze too much performance out of a single filter stage. Like my LC tank problem mentioned several paragraphs back, I would find that I needed high Q (and maybe some Gain to boot) to make the single stage's 6 dB per octave rolloff seem like it was actually earning its living, but would run into instability problems (that's when sharp filters become sine-wave oscillators and "ring" continuously at their center frequency). Finally I bit the bullet and built two stages (giving a total rolloff of 12 dB/octave) and decided I could stagger their tuning a little, if I wanted. Then when I heard the result, even with identical parts values (and identical center freq's), I was satisfied enough with the gentle "sea-shell at the ocean" sound (no ringing, but a little distortion on W1AW's monster signal) that I left things alone and settled for the circuit values you see in the schematic above.

[3/25/05 UPDATE: I changed the 2nd filter's ground resistor (nominally 560 ohms) to a 1K ohm trim potentiometer, so I could vary the 2nd filter's center frequency a little... after a while the constant "seashell" sound of a narrowband filter gets tiring to listen to.]

Now W1AW's signal is suppressed enough, when I'm tuned a couple of KHz away, that it doesn't pierce through annoyingly; yet any weak signals in the passband are accentuated just enough to make their presence known. RTTY sounds downright musical!

The audio is then routed to the output jack, mounted in the front panel of the copper chassis, into which I plug a 1-ft audio cable leading to the Radio Shack amplified speaker.

So yes, I do have quite a bit of audio gain going on here. But I have had very little problem with squealing or howling or motorboating... sometimes if the Radio Shack speaker is too close to the receiver box, a little bit of acoustical resonance (vibration) builds up when listening to a strong CW tone, right in the middle of the filter's passband. I simply move the amplified speaker a little farther away and that usually solves the problem.

Strange Experience

The only really strange "funny" that I've experienced was some intermodulation-- one weekend when there was a lot of strong RTTY on 80 meters (probably a contest), I was mystified by a most unusual "new" form of modulation on the air... I heard Morse Code (CW), but instead of the dots and dashes being made up of pure tone, they were made up of the "beadle-beadle" sound of a RTTY transmission! In other words, I was hearing some RTTY being "gated" on and off by a station transmitting straight CW! It took me a couple of minutes to figure out (with the help of my "real" Kenwood TS-520S receiver) that there were indeed two strong stations, one sending CW and the other sending RTTY, some KHz above my colorburst crystal frequency of 3.58 MHz, and my RixPix front-end was mixing them in its overloaded detector stage. So, Pixie builders, beware of strong signals lurking just beyond your crystal's neighborhood. A better receiver would reject them as out of the immediate tuning window.

Future Enhancements

What next for the RixPix? Oh, I don't know. If you're like me, you go through alternating spurts of creativity and longer intervals of laziness where you just don't feel like "getting into it"... so I don't know if I'll ever really add all of the following, but I'd *like* to:

A decent RIT

Sidetone so I can hear my CW as I send

Some easy way of switching crystals and Pi filters for multiband operation

More power out while preserving most of the "spirit" and design of the original Pixie

An enclosure that, for once, looks halfway professional (my mechanical skills suck, in general)

Maybe - just maybe - taming an LM386 chip and building the entire audio amp and speaker into that dream enclosure.

.... And then I woke up.

Back

The AGC-80

A Regenerative Receiver with AGC for 80 Meters or 3-10 MHz Shortwave

March 23, 2006 by Rick Andersen, KE3IJ
[Revised 12/2/06, 2/16/07, 3/10/07]

Here's a Regenerative Receiver project that I designed for the 80 meter Amateur band, but which can also be used in a wider-tuning configuration that covers approximately 3 MHz to 10 MHz, for Shortwave (World Band) listeners.

Built in the same style as my previous "40-Meter Tweeter" which can also be found at my Radio Projects menu at http://www.ke3ij.com/radios.htm, this radio features:

* Colpitts-style regen detector which eliminates the need for any tickler coil
* 3-10 MHz tuning set by pc board trim capacitor, but main panel bandspread via varactor diode tuning which is renamed Main Tuning and covers a band of frequencies variable to 150 KHz from where the pc board trimmer is set
* An audio-derived **Automatic Gain Control** (AGC) circuit that helps prevent overload and blocking by strong signals
* Low input impedance matches 50 ohm antenna system -- giving relatively little AM overload/bleedthrough (although you may want to add a 3.8 MHz bandpass filter after the antenna jack and input diodes; see text and schematic below).

This is version 1 of this design, so it is to be expected that there will be some modifications, especially as I get feedback from other builders who try the circuit out for themselves. Other features that I will probably include in the next version of this basic 80 M regen are:

* Audio filtering: Variable frequency plus the ability to vary the filter smoothly from a *bandpass*, to a *flat*, to a *notch* response
* I may add a zener diode regulator -- So far, the 80 M prototype drifts in frequency very slightly; not nearly as much as the 40 meter version did, which absolutely required a zener regulator
* A built-in audio amplifier and speaker. Right now there is a headphone jack, which I am running into a Radio Shack amplified speaker (they still have 'em! Get 'em while they're hot and not-yet-discontinued! $12.99 last I checked)
* An S-Meter circuit. I actually designed one with the AGC included in this radio, but had some problems with the "zeroing" of the meter tending to drift off zero after a while -- so I left it out of this first version and plan to include it in the next, when the bugs are worked out
* I will probably build a switched crystal converter for the front end of this design and make the radio into a Regenerodyne multi-band. Have not built a Regenerodyne yet but it is a wonderful idea and could make for a simple, basic station receiver

The Circuit and Description

Though I built the entire radio on a piece of 5x7", double-sided copper-clad pc board (from Radio Shack), with front panel and partial sides and back, (see photos at bottom), I decided to break the schematic up into 3 sections for easier analysis, below.

First, the "front-end". Built around Q1, a common 2N3904 NPN silicon transistor, we have an RF amplifier/buffer to keep the regenerative detector isolated from the antenna. Regen builders are aware that a swaying antenna on a windy day can cause the oscillating detector frequency to sway also, which of course is very annoying. On top of that, the oscillating detector is actually

transmitting its signal out the antenna and causing potential interference. This front-end RF stage keeps that from happening. I am able to verify that this stage isolates the detector pretty well in that I have an ATU (Antenna tuner or Transmatch) connected between the external antenna and the receiver. With no isolation, the regen can be detuned by turning the ATU knobs back and forth around the resonant spot on the ATU. With Q1's circuit in place, hardly any frequency shift occurs.

Now as far as *gain* or amplification is concerned, we home-builders always assume "the more, the better". I have learned that this is not always the case -- especially with regens. Regenerative circuits are already extremely sensitive, which means that if you shout in their ears, their little eardrums are going to hurt (overload). A problem I've often encountered is what is known as "blocking" -- when a very strong signal overloads and swamps the detector, being stronger than the oscillator "injection level" of the detector itself. So the detector's frequency is "pulled" and it tends to "lock onto" the incoming signal, sometimes stopping oscillation altogether. [We're assuming that we're in a ham band listening to CW or SSB voice here, which requires the Regeneration control to be advanced far enough that the detector is now oscillating.]

When this strong-signal overload occurs, your CW tone will chirp violently, and single-sideband voice sounds completely unintelligible. That's why I decided to add an AGC circuit to my regen, which I have not seen anywhere else (correct me if I'm wrong).

This same stage that is the RF amp and buffer, doubles as the AGC'd amp. Looking at the first schematic, below, we see a 50-ohm antenna input via a BNC connector (you can use the standard SO-239 ham connector here if you like) that immediately connects to a pair of parallel, oppositely oriented small diodes. This is a clipper that ordinarily doesn't have any effect on the incoming signal, which is in the microvolt region. If a strong voltage spike were to come through, the diode(s) would turn on at .6-.7 volts and conduct the excess to ground, protecting the receiver from front-end zapping.

Next, the incoming signal goes ***either*** to an optional LC bandpass filter peaked at about 3.8 MHz, of which I give two variants in the schematic diagram, ***or*** straight to a .001uF coupling capacitor and on into the first transistor stage... Let me explain:

NOTE! All of the following, in italics, assumes that you are using the AGC-80 receiver in its narrow-band mode for the 80 Meter Amateur Band (3.5-4.0 MHz). If your intent is to use the receiver as a 3-10 MHz "Shortwave / World Band" radio, you will want to <u>ignore</u> the following, since you don't want a front-end filter to restrict your wide-band tuning.

The original schematic published in March 2006 showed the straight-through connection. When I designed the circuit, I failed to take into account the filtering action provided by my resonant antenna tuner.... and later realized that there is some ***out-of-band "bleedthrough"*** *[interference from carriers far-off in frequency] if your setup lacks a resonant ATU and you connect your AGC-80 directly to an external antenna. To remedy this, I inserted a 150 pF ceramic capacitor in series with a small T-50-2 toroid with roughly 20-35 turns of #28 enamelled wire on it. Theoretically you need 12 uH with a 150 pF cap to resonate at 3.75 MHz, the middle of the 80 meter band. The low impedance (50 ohms) requires that the L and C be in* ***series****, rather than the often-seen* ***parallel*** *LC "tank" type of bandpass filter.*

In practice, I wound about 30 turns and then began subracting turns, one by one, until I heard a peak in the loudness of the background static, with the receiver tuned to about 3.85 MHz. I can't recall the exact number of turns needed, but since moving/squeezing the windings on the toroid does have some effect, it is best that you do what I did and find the exact number of turns that peaks your radio at 80 (or 75) meters. Then, drip some hot wax from a birthday candle onto the toroid, to hold the turns rigidly in place. This 50-ohm series bandpass filter will knock out the out-of-band bleedthrough almost entirely.

A NEWER AND BETTER BANDPASS FILTER

Later (February 2007) I came up with a sharper-cutoff 50-ohm bandpass filter, based on a "PI" ***lowpass*** *filter preceded by a series capacitor of .001 uF; this cap and the original circuit's .001 uF*

*blocking cap (giving a **hipass** filter response) combine into a narrow **bandpass** filter with sharp skirts, centered on approximately 3.85 MHz in my prototype-- see the "optional" filter between the "X's" in the schematic.*

Notice that I use a 1-inch length of plastic tubing-- cut from a McDonalds straw(!)-- as the coil form for the inductor in the PI-filter. Pierce 2 small holes in the middle of the 1" section of straw, with about 1/4 inch between the holes. Within this 1/4 inch, wind approximately 15 turns of #28 enamelled copper wire, close-wound, bringing the ends of the 15-turn coil through the holes and out each end of the straw. Add or subtract a turn, or squeeze together / separate the turns slightly, until the received signal strength peaks at maximum, then drip some melted candle wax onto the coil to hold the turns in place. This filter will sharply attenuate out-of-band signals.

***NOTE:** The "McDonalds straw" bandpass filter just described was not designed because the simpler series LC (12uH and 150pF) was deficient. The simpler LC worked just fine in my prototype. I just decided to try a fancier design, to prove to myself that it would work just as well, but also allowing for the possibility that some Hams attempting to duplicate my receiver may live at a location where there might be stronger out-of-band interference than I have at my QTH, and would need a better input filter than my original design had offered. So here I offer you **three** options, assuming you're using an external antenna system with a 50 ohm impedance coming in to the radio:*

***1)** No input filter at all, which works, but you do notice a bit of 'busy' background carriers and noise. But if your antenna tuner is of the "resonant peak" type (as opposed to the more common "Pi" or "T" types), you will be able to get away with this option-- let the ATU provide the front-end rejection for you! Still, the 50 ohm front-end impedance, by itself, does a lot to correct the 'AM blanketing' problem that plagues simple receivers.*

***2)** A simple series LC filter centered on the middle of the receiver's tuning range [approx. 3.8 MHz]. I used a 150 pF ceramic capacitor and a 12 uH coil, with the 12 uH being attainable in one of 3 ways:*

***a)** As described above, about 20-30 turns of #28 enamelled copper wire on an Amidon T50-2 (red/gray core) toroid;*

***b)** About 60 turns (2 layers, 30T each, close-wound) of #28 wire wound on a McDonalds straw;*

***c)** About 18 turns #28, close-wound on a plastic prescription pill bottle with a 1" diameter -- these are approximate turns values and you will need to adjust them for peak reception. (The #28 wire gauge is not sacred, either. It's nice and thin, however, and I have a roll of it, so I tend to favor it!)*

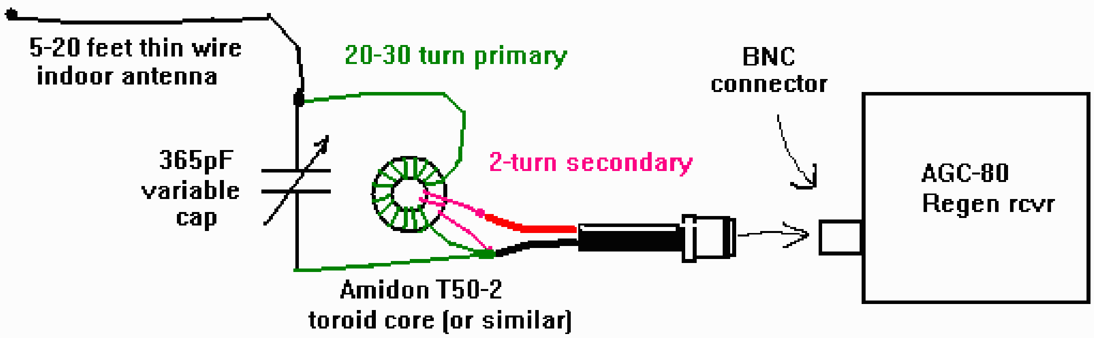
***3)** A combination Hipass/Pi-Lopass filter with fairly steep skirts, the circuit details of which are shown between the blue X's in the schematic diagram below.*

*[I'm also thinking ahead to a possible "**Regenerodyne**" approach for the future, where a crystal converter stage will precede the AGC-80's input stage, giving multi-band reception. The better the bandpass filter, the better the **image rejection** [the Image Frequency is an unwanted product of the heterodyne mixing process].*

***Here's Another Option:** <u>Use an inside antenna!</u> Maybe you're an apartment dweller who can't string up an 80 meter dipole antenna, which should be around 130 feet long. No problem-- a thin wire anywhere from 5 to 20 feet long can be run along the perimeter of the room. This is a high-impedance, electrically-short antenna that is transformed down to the required 50 ohms by a tuned LC-tank with low-impedance secondary winding on the "L"... the short wire plus the LC-tuner/transformer guarantee that this indoor antenna is sensitive only at the sharp peak frequency of LC resonance. No out-of-band AM blanketing here, either!*

QUICK & DIRTY SHORT ANTENNA for the AGC-80 REGEN RECEIVER
3/24/06 by R. Andersen, KE3IJ

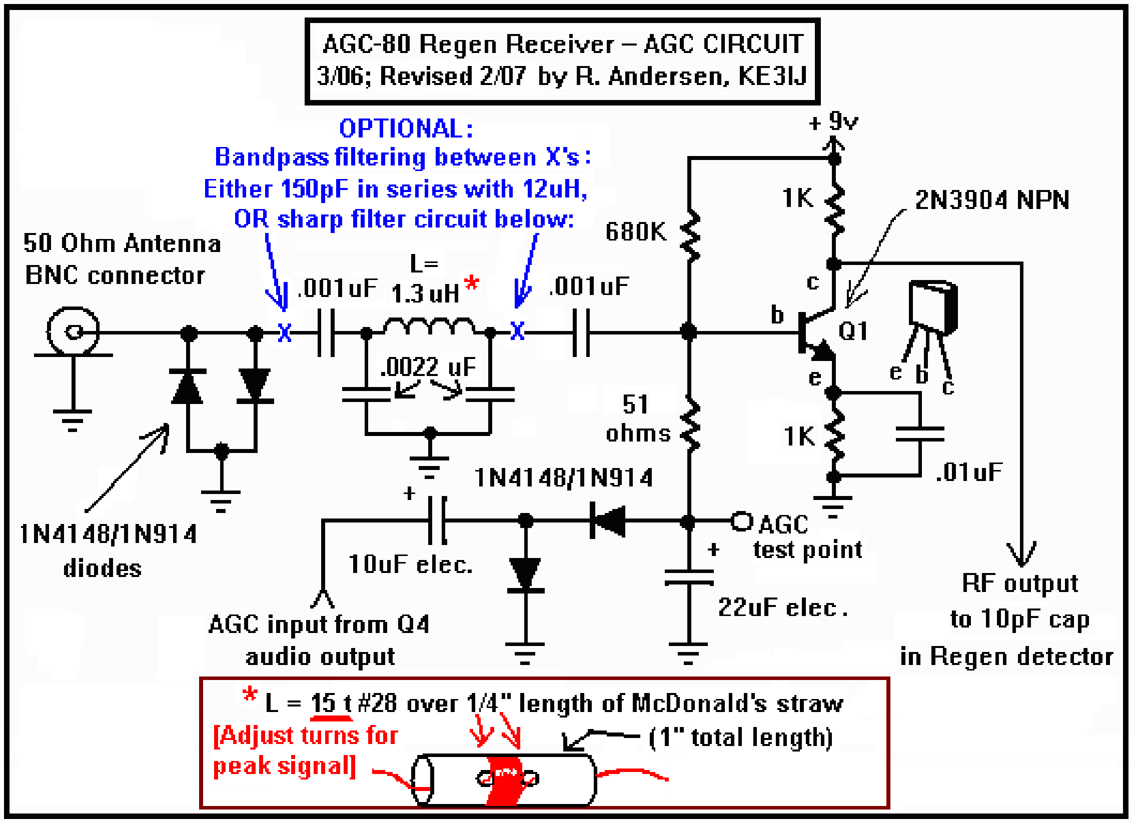
When you don't have either a 50-ohm external antenna, or an electronic "active antenna," you can still get fair reception by adding the following "passive" circuit to your AGC-80. Just string up a piece of thin wire in the room, 5-20 feet long, and connect it to an L-C circuit as shown below. The coil has a 2-turn secondary which transforms the high antenna impedance down to the 50 ohms that the AGC-80 requires. Plug the secondary's output into the antenna BNC connector on the AGC-80. Tune the antenna cap carefully and you'll hear the signals you're looking for. Use that cap to peak the loudness.



Back to the description of the AGC-80 schematic: The desired signal goes through the [optional filter and] .001uf blocking capacitor and into Q1's circuit, which looks like a standard common-emitter amplifier. It is, except that the lower base bias resistor is quite small compared to what you'd expect-- the impedance seen "looking into" the amp is 50 ohms, which (presumably) matches your antenna system, and has a great effect on eliminating out-of-band AM blanketing that so often plagues simple homebrew receivers. The junction between this 51 ohm resistor and the 680K bias resistor above it, is where the AGC action takes place - telling the base of Q1 to vary the transistor's gain in such a way as to compensate for any changes in incoming signal strength.

Looking at the circuitry below that 51 ohm resistor (47 to 68 ohms will work here, by the way), we notice a 22 uF electrolytic capacitor; this cap integrates and stores the AGC voltage, which voltage is generated by the "charge pump" circuit to its left (the 10 uF electrolytic and the two diodes). This is the heart of the AGC.

The input to the 10 uF cap is taken off the output of the 2-stage audio amp to be described later. The + side of that cap sees a DC bias voltage upon which a large-swing audio signal is riding. The 10 uF cap blocks the +DC but passes the large AC swings to the diodes, which rectify them into a negative varying DC, which then spills into and charges up the 22 uF AGC cap. A *negative peak detector*, in electronics lingo.



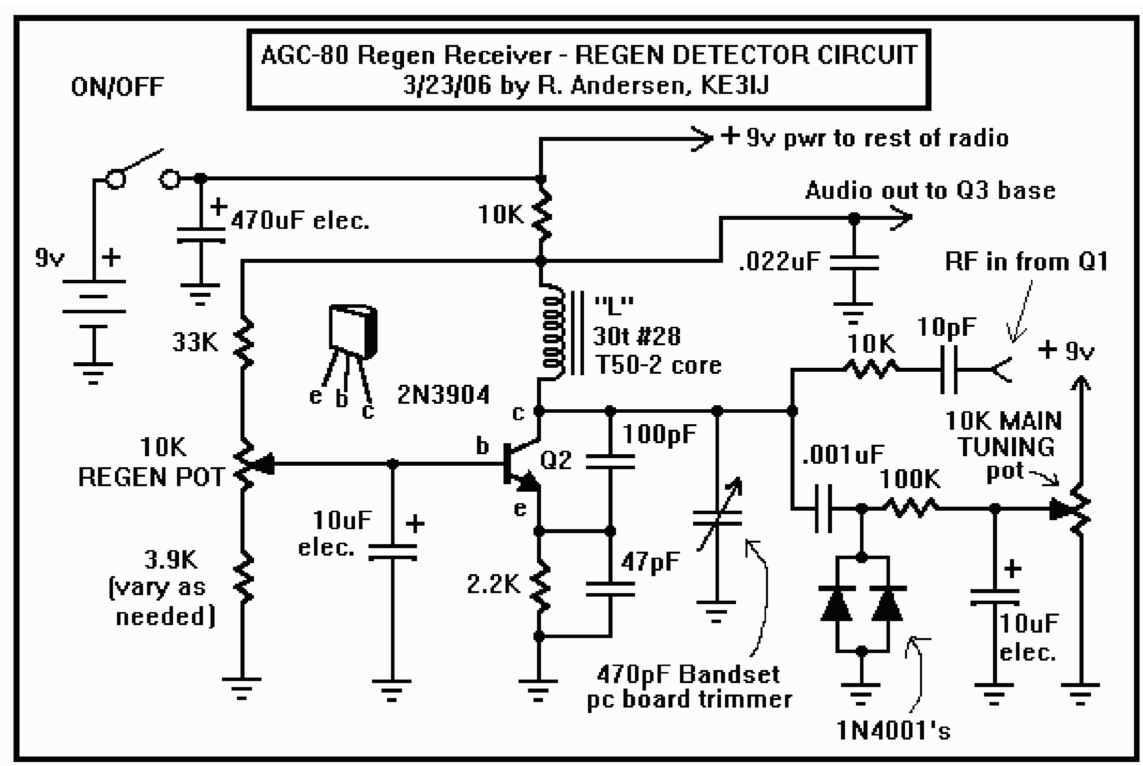
This negative bias goes more negative as the audio gets louder; less negative as the audio gets softer. Applied to the bottom of the 50 ohm resistor, this negative AGC bias has a back-and-forth "tug of war" with the voltage *above* the 50 ohm resistor -- Q1's base voltage -- which is established by the upper base resistor of 680 K ohms. The overall gain of the Q1 amp is determined by the DC bias at its base. So when incoming signals get loud and strong and try to overload our sensitive regen detector, the DC bias on Q1's base is automatically pulled down, lowering the gain of the front-end, so less signal gets to the detector's sensitive ears. When the SSBer finally shuts up and there's an absence of incoming signal, the negative AGC voltage decreases, the 680K pulls Q1's base back up, and the front end gets more sensitive, letting more signal in for the detector.

Thus, the AGC is a *negative feedback* circuit which always "bucks the trend" and tries to keep the volume approximately the same. Now you can hear the background level come back up when the guy stops yapping, and go way down when his +30 dB/S9 signal blasts through on the next transmission, performing just like your "real" radio does. The "blocking" problem that plagues regens is now gone! Probing the 22uF cap with a digital voltmeter shows about 790 millivolts when all is quiet, dropping to about 500 mV when a moderately strong signal is coming through, to as much as *2 volts negative* or so when extremely loud foreign broadcast stations are tuned in.

NOTE: I revised Q1's emitter resistor in the AGC circuit on 2/15/07, changing it from its original value of 4.7K ohms down to 1K ohms. This seems to have increased the sensitivity of the radio, although it also brought up the background noise (with antenna disconnected) somewhat. I also added a 10K resistor in series with the 10 pF cap leading from the AGC circuit to the Detector circuit; this was necessary to prevent a tendency toward some "pulling" that cropped up after I lowered Q1's emitter resistor to 1K ohms. If this modification does not seem to work well for you (i.e., if very strong signals "pull" or "block" the detector frequency, which the AGC is supposed to prevent), feel free to go back to the original 4.7K emitter resistor, and remove the 10K that is in series with the 10 pF cap feeding the tank circuit of the detector.

Next, the Regenerative Detector itself. This is the heart of the receiver, and could be built as a stand-alone, minimal Regen radio. [See A Single Transistor, Big Loop AM Radio for details.] I have decided that the Armstrong 'tickler-coil' type of regenerative detector, seen everywhere, is no

longer my favorite. This one is. I call it a Colpitts-style detector because it is essentially a variation on the Colpitts oscillator. It does away with the need for a pesky, fussy tickler coil with its turns ratio, coupling distance, and phasing nuisances. The Colpitts oscillator (which this actually is, but for AM is operated just below the point of oscillation) gets its positive feedback or *regeneration* through a "capacitive voltage divider" -- the two little 100- and 47 pF caps hanging off the collector, base and ground. The only inductor you need is "L", shown as a 30-turn toroid coil in my prototype. ***[12/2/06 update: You may also want the optional front-end LC filter; see text above.]*** *If you can't get your hands on some Amidon T50-2 toroid cores, don't fret! You can wind your own air-core coil on a small plastic pill bottle, a cardboard toilet-paper roll, whatever. The point is that this Colpitts design makes your coil very simple.*



This Colpitts circuit is not my own (although the particular parts values are); you can find it on various Regen radio websites as an alternative to the Armstrong variety. My previous design, the "40-Meter Tweeter", used a variation of this circuit (except with PNP transistors, which makes the circuit look "upside-down" in the schematic), as do the "Universal" and the "VHF/Aircraft" designs at my webpages. It's a very handy circuit that has become the configuration of choice for my regen designs.

The detector is tuned by means of the simple "L" coil, mentioned above, and a variable capacitor as a Tuning control (in the simplest, stand-alone version of this circuit). In my first tack-soldered "spider-web" slap-together of this circuit, I had a good old metal plate 365 pF variable capacitor as my Tuning control. With 30 turns of #28 wire on a T50-2 toroid, I could tune from about 3 MHz up to 10 MHz. ***This is probably how you want to build the receiver if your main interest is in Shortwave listening.*** If your interest is in the ham bands, of which I chose 80 Meters, that 365 pF variable gets replaced (as per the schematic below) with a pc-board mount trim capacitor, 470pF screw adjust [mine came from **Electronix Express** in New Jersey, USA].

I add in a "bandspread circuit" (as you can too, if you're a SWL and you want bandspread in addition to your panel-mounted 365pF Main Tuning cap) which is a varactor diode circuit tuned by a 10K ohm potentiometer. But because my radio focuses on the narrow band of frequencies making up the 80 Meter band, I move the "bandspread" pot into the main position on my front panel, and rename it the Main Tuning control. The Shortwave listener's 365pF variable cap moves (as I mentioned earlier) onto the circuit board as a 470pF trimmer called the Band-Set cap. So the pcb 470pF trimmer sets you in the 80 Meter band initially, when you first calibrate the receiver;

then you leave it alone and do all your tuning from the front-panel varactor pot. That's why the schematic below shows the 'bandspread' pot as the Main Tuning pot. Be sure you understand this. You can configure the receiver either way; I chose to limit the tuning to the upper half of 80 meters (SSB/AM voice part of the band), so I can listen to all the nasty old codgers and weirdos that inhabit the SSB portion of 75 Meters late at night.

The Main Tuning (the SWLer's "Bandspread") pot is used to vary the + voltage (reverse bias) on 2 parallel 1N4001 rectifier diodes. These are much more common (and cheaper) than a real varactor diode; they work just fine [although they are nonlinear in their tuning response; you will find that signals are compressed on one end of the dial more than on the other]. I found that 2 of these diodes were needed to give a frequency spread of about 150 KHz across the tuning dial. This isn't quite enough to cover 80/75 Meters but if I were to make it wider, it becomes that much more difficult to tune SSB signals in and "clarify" them easily (tuning becomes too touchy).

The capacitance of any diode varies by a few picoFarads when you vary the reverse bias across it; this small variation is effectively in parallel with the Bandset cap (the 470pF trim cap or the SWLer's 365pF panel cap) through a .001uf DC blocking cap.

The radio signal itself enters the regen detector through a 10pF capacitor *[and series 10k reistor, added 2/15/07]* connected between the output of the RF/AGC amp (Q1) and the "top" (the Q2 collector point) of the LC tank circuit formed by "L" and the Bandset tuning cap.

The receiver is calibrated initally by listening, with a "real" radio set to SSB/CW mode nearby, as the Bandset trimmer cap is turned back and forth. At some point, you should hear a quick "WHOOP!" as the carrier passes through the frequency your commercial radio is tuned to. I calibrated my prototype for 75 meters, so I tuned the store-bought receiver to 4 MHz (the top of the band) and then turned the screw on the 470 pF pcb trim cap until I heard the "whoop". Then I very carefully fine-tuned the screw adjustment to get the regen to be oscillating as close to 4 MHz as possible (taking into account the frequency-pulling effects of a metal screwdriver!). The regen's Main Tuning pot was set to maximum (full clockwise) for this. The regen receiver was then able to tune from 4 MHz down to about 3.85 on the counter-clockwise end of the tuning pot. Since then I've lowered the tuning by 50 KHz, cuz I wanted to. You can set it anywhere you want. In fact, you can set it for 40 meters if you desire. Or, one of the Shortwave Broadcast bands. (Of course, if you use it for SW listening, you will be tuning to frequencies higher than the 80 meter band, which means you must disconnect any 80-meter filter you may have installed, as an option, after the two parallel diodes hanging off the antenna jack to ground. This, in turn, will increase the likelihood of AM broadcast overload from some of the powerful stations in the band; you may need to install a filter for the particular band you're interested in, and/or use a resonant antenna tuner.)

As mentioned in the AGC section above, varying the DC bias on the base of a transistor in the common emitter configuration, varies its amplification or gain. So we use another pot as our **Regeneration Control** whose wiper voltage varies the DC bias at regen detector Q2's base. A 10uF electrolytic bypasses potentiometer noise (which can be quite noticeable with this sensitive, oscillating circuit). Resistors above (33K) and below (approx. 3.9K) the Regen pot act to scale the "active region" of the regeneration control so that it occupies at least half of the travel of the pot. In other words, the transistor Q2 only trips the threshold into regeneration at some + base voltage, but then fades out if that base voltage is adjusted too high. The result is that there's only a small spot on the dial where regeneration occurs. We want to spread that out (in the same way that the Bandspread control works with tuning) so we "pad" the Regen pot with extra resistors above and below it, which effectively reduces the percentage of voltage-variation that the pot affects, thereby "spreading out" the "active regen region" across the pot knob's travel. (Clear as mud?)

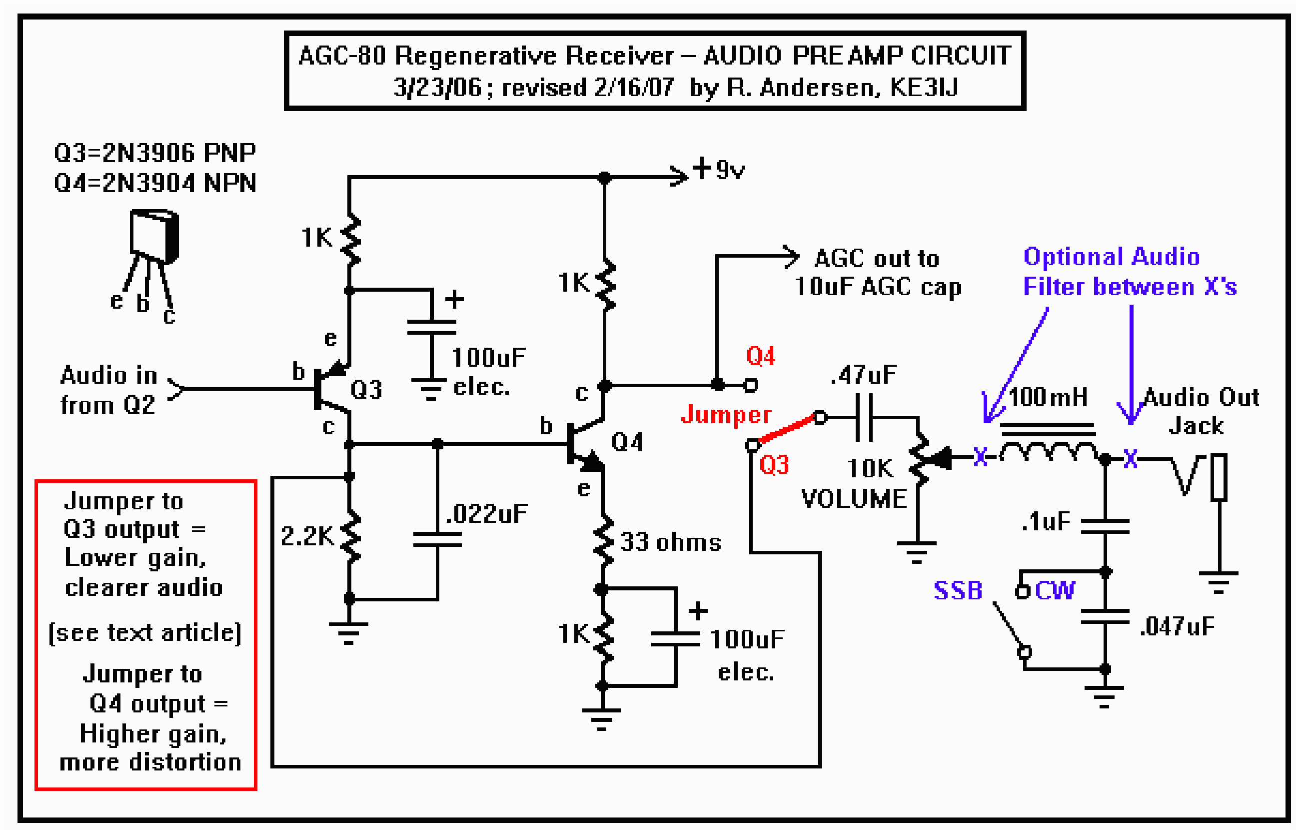
Please note: ***You may have to adjust that lower 3.9K ohm resistor to some other value in your version of this radio.*** It may be more convenient to put a small 10K ohm trim pot in place of the 3.9K, which I did in my protoype. Once the trim pot was set to where my Regen control acted the way I wanted it to act, I removed the trim pot, measured it with an ohmmeter, and came up with 3.9K. So then I put a 3.9K in its place, and that's why the schematic shows 3.9K. You may need to modify it.

You definitely need to calibrate that lower resistor so that you have at least the first quarter-turn or so, up from full counter-clockwise, as an area where the detector is NOT OSCILLATING, so that you can bring the detector right up to the point *just before* oscillation, for good sharp AM reception. Advancing the knob further will cause the detector to start oscillating (you'll hear the background noise come up) and allow you to hear sideband voice and CW (Morse code) transmissions.

NOTE: All regens suffer, more or less, from the following: Once you pop the detector into oscillation, continuing to advance the knob causes a substantial de-tuning of the oscillator frequency. You can use this defect as an advantage -- a "clarifier" for SSB that may be less touchy than the tuning knob -- but I wanted to make sure you were aware of this. We normally don't go "too far" into oscillation when listening to SSB or CW, so as not to de-tune the receiver "too far off" from where we were. Annoying, but a fact of life in the Regen world. By the way, I have read that other Regen designs, such as (possibly) the Armstrong "tickler-coil" variety which uses a variable "throttle" cap instead of a potentiometer for regeneration control, do not suffer as much from this problem of detuning via the regen knob. Someone else has suggested that my fondness for using the Amidon T-50-2 red-gray toroid cores might contribute to the phenomenon-- they may be saturating magnetically when the circuit is set into oscillation, whereas air-core coils would not. But this detuning happens even without toroids in the circuit, which I verified recently when I built the big loop AM radio. So I'm still pondering these claims. Meanwhile, these circuits work, and as minimalists we're expected to put up with some inconveniences in the interest of simplicity of design.

By the way, because the ham-band configuration only allows a range of 150 KHz, you'll have to re-tune the bandset trim cap with a screwdriver to listen to the other parts of the band. E.g., mine tunes from about 3.8-3.95 MHz, which is most of the phone (voice) band (75 meters). To hear the CW (code) portion, I need to tighten up the screw on the Bandset cap. Now I'll be tuning 150 KHz from wherever I re-tuned the Bandset (e.g., 3.5-3.65 Mhz). You could solve this problem by installing a small-value capacitor (something in the low pF range) that can be switched in- or out- of parallel with the Bandset cap, giving you CW-only versus VOICE-only sub-bands within the 80 Meter band. There are lots of possibilities you could come up with. (Remember, we're minimalists, building minimalist receivers. Add or subtract bells and whistles to your liking, but don't weep if I don't have something that you want in yours! Find out how to add it and DO it!)

Finally, the Audio Preamp. This is the final section of my 3-part schematic. First, go back to the 2nd schematic (the detector) and notice the 10K resistor above the inductor "L". That's our audio pick-off point. The audio is actually detected in Q2 as the "beat" between the incoming signal from the 10pF cap and the internally-oscillating dectector. For AM, the base-emitter junction of Q2 acts like a diode detector.



I like to direct-couple audio stages whenever I can. It saves me having to find the right coupling caps. So the schematic for the 2-stage audio preamplifier, above, shows the base of a 2N3906 PNP directly coupled to the junction between "L" and the 10K resistor. (If you want to use the audio amp in another application, insert a .22uF cap to block the direct DC at the input, then add a 220 K resistor from Q3's base to collector. This gives DC blocking and internal biasing for Q3. I chose to go direct.)

Also hanging off that L/10K junction is a .022uF cap to ground. This cap shunts the remaining RF frequencies to ground, leaving just the audio, which we want to amplify without amplifying any RF.

Q3 is a 2N3906 PNP common-emitter amplifier, whose output is at the collector of Q3 / top of the 2.2K load resistor. That resistor has another .022uF across it, for further filtering and softening of the audio signal. There is enough audio output at this point to comfortably drive an external Radio Shack Amplified Speaker, but not quite enough signal for loud crystal earphone or loud 2000 ohm magnetic headphone reception. Also, we need more amplification to generate a good AGC signal..... so we add one more stage (Q4), which is a 2N3904 NPN, also direct-coupled to the previous stage. This is another common-emitter stage, with a 33 ohm "swamping" resistor added to the emitter to knock out a mild tendency toward "motorboating" that suddenly appeared when I built the circuit into the copper box that you see in the photos.

[And before you ask, yes, you can substitute a 2N2222A for the 2N3904 NPN, and a 2N2907A for the 2N3906 PNP. You *may* have to adjust some resistor values but I doubt it.]

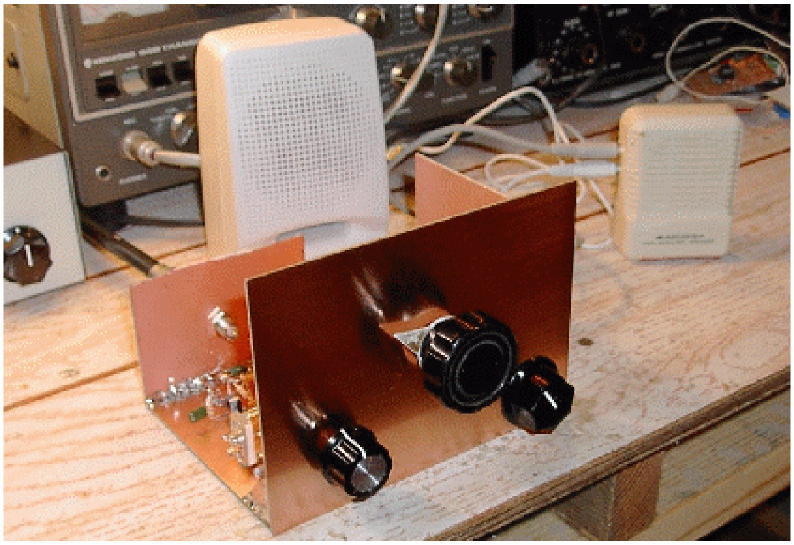
Now the signal (at Q4's collector) is DAMN loud--- it overloads the Radio Shack speaker amp, and drives the headphones to a pretty loud level; it's just what we need, however, for our AGC signal. So we send it directly back up to our first schematic, where it enters the + side of the 10uF cap in the AGC charge pump circuit. Meanwhile, we split it off and send the remaining audio to a 50K **Volume Control** pot on the front panel, which also doubles as an **ON/OFF** switch for the radio. (The 50K ohm pot could also be 10K-100K; not a critical value. My prototype uses a 50K because that's all I had lying around the bench; the schematic shows a 10K for uniformity with the other pots in the radio.)

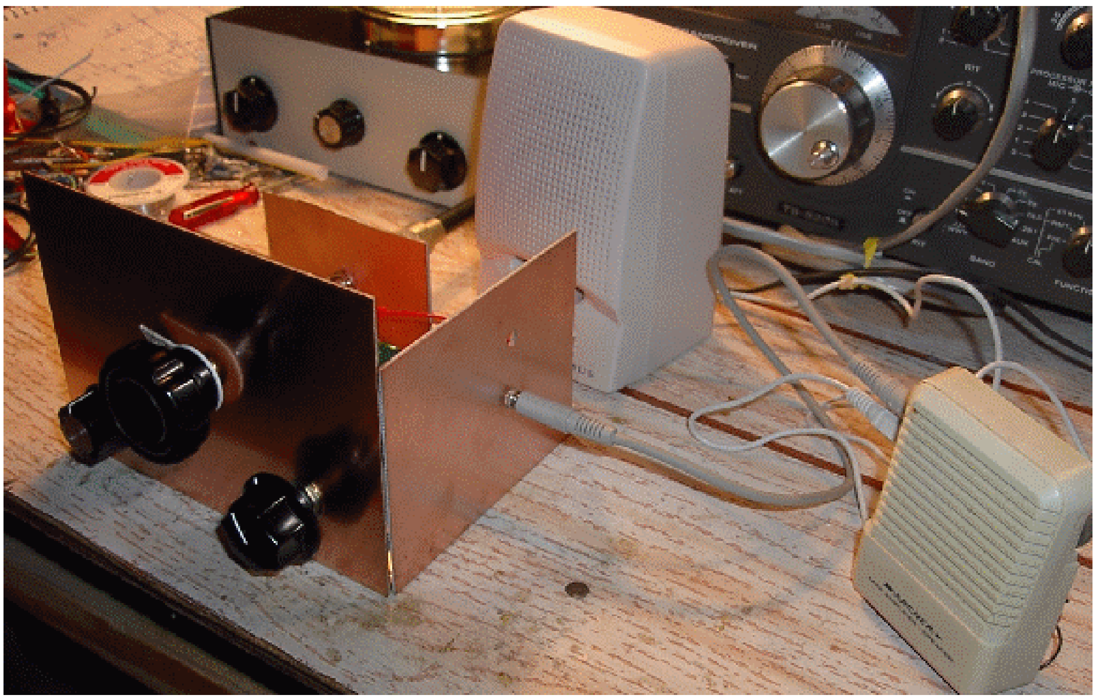
NOTE: This extra stage of gain (which is necessary for the AGC) does add a little "fuzzy" distortion to the audio. If you prefer a cleaner audio, tap it off of the previous stage, Q3's collector. The Radio Shack amp prefers this, because it has an internal preamp of its own. But if your headphones are crappy and not too sensitive, tap your audio off of Q4's collector -- much louder. I leave it up to you to decide. The schematic shows the coupling cap and audio output jack tapping off of Q3.

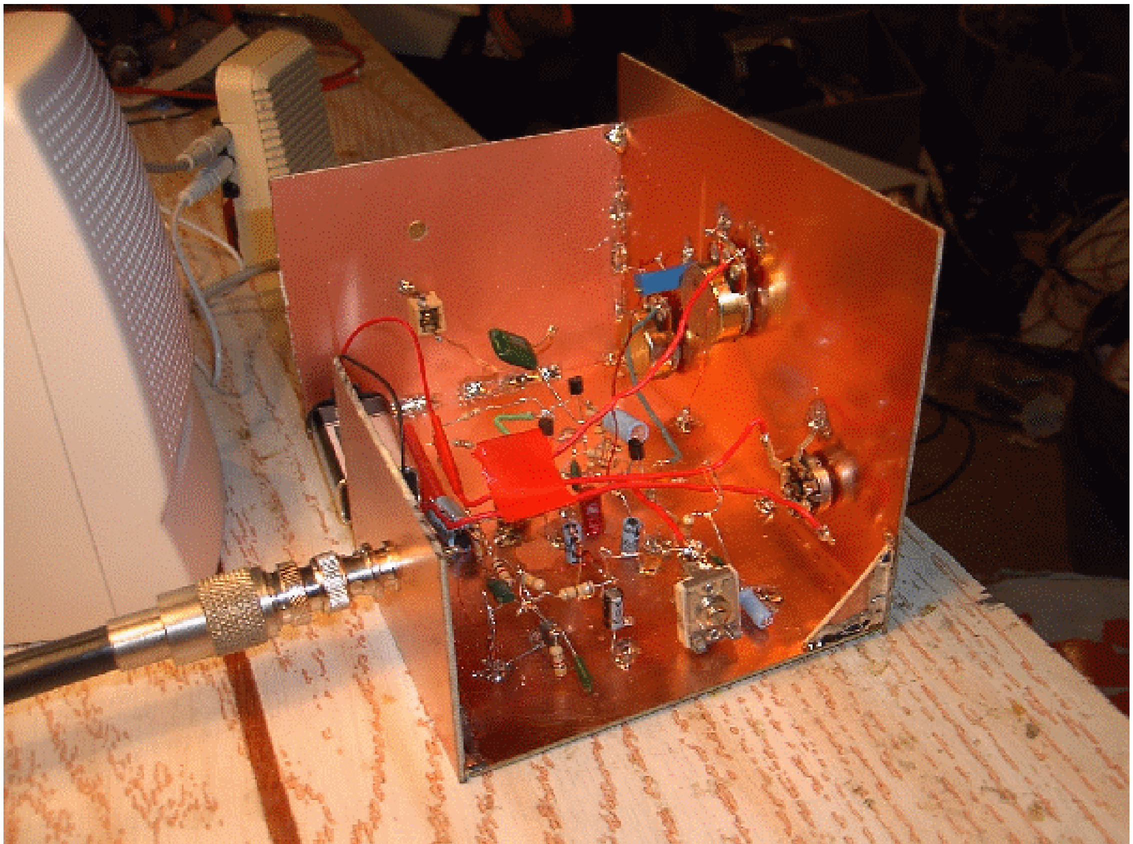
[2/15/07 modification:** As shown in the updated schematic of the audio section, I added a passive audio filter to kill some more of the high frequencies (whistling heterodynes, etc.), which you may leave out if you don't want that option. I happened to have a 100 millihenry inductor from Electronix Express (the blue cylindrical inductors) whose internal DC resistance measures about 106 Ohms (good to know since higher winding resistance lowers filter Q). After trying various filter configurations, I settled on the passive lowpass filter you see in the schematic, with 2 capacitors in series (for voice reception) and one of them shorted (to lower the cutoff frequency) for CW reception. Of course, this requires another switch on the front panel. Again, feel free to modify as you see fit, or leave the filter out altogether.**]

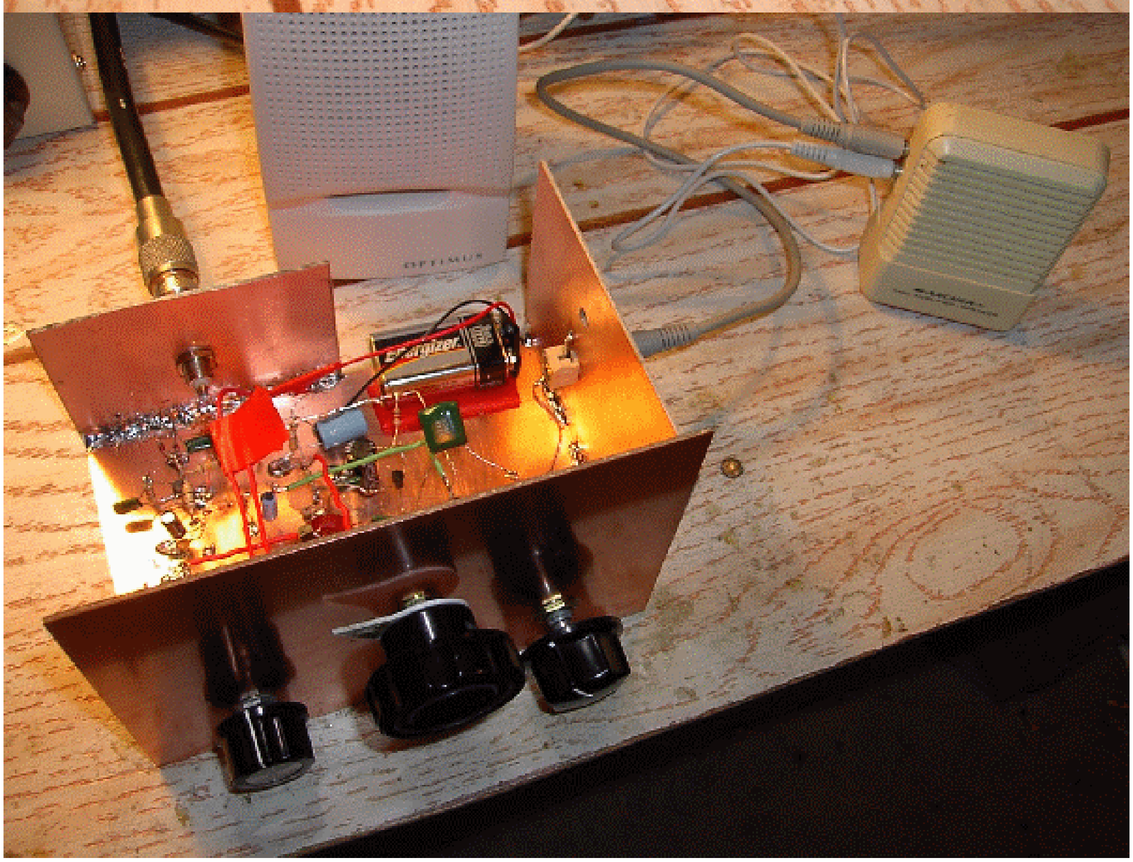
Just for good building practice, a 470uF electrolytic cap sits across the +9v lead and ground (on the radio side of the power switch, not the battery side!) which keeps noise and unwanted oscillation away.

Here are a few pictures of my prototype (copper-clad, "Ugly-Construction", no tuning dial yet, mismatched knobs, Oh ain't she a beauty!). The lower left knob on the front panel is the On/Off switch and Volume control. The middle knob is the Main Tuning (varactor pot). The lower right knob is the Regeneration control. The Radio Shack (*"Archer"*) amplified speaker plugs into a miniature audio jack at the right side of the AGC-80. A hi-fidelity speaker from a pair of Optimus computer speakers can be seen behind the AGC-80 and connects to the auxiliary output jack on the Radio Shack amp. Audio quality off Q3 is good; audio off Q4 is a bit fuzzy, but nice and loud. (My Kenwood TS-520-S "real rig" graces the background, but you're not supposed to be looking at that.)









And that's it! That's my AGC-80 Regen Receiver with Automatic Gain Control which I feel gives a substantial improvement in regenerative radio performance. I hope you will consider putting one of these together and letting me know how yours performs. Feel free to email me at rick@ke3ij.com

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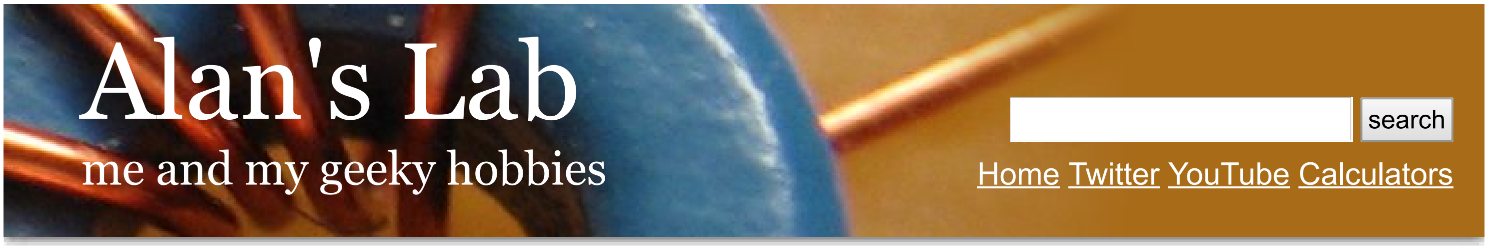
[Back]()



Multimeter RF Power Add-On

2007-09-09

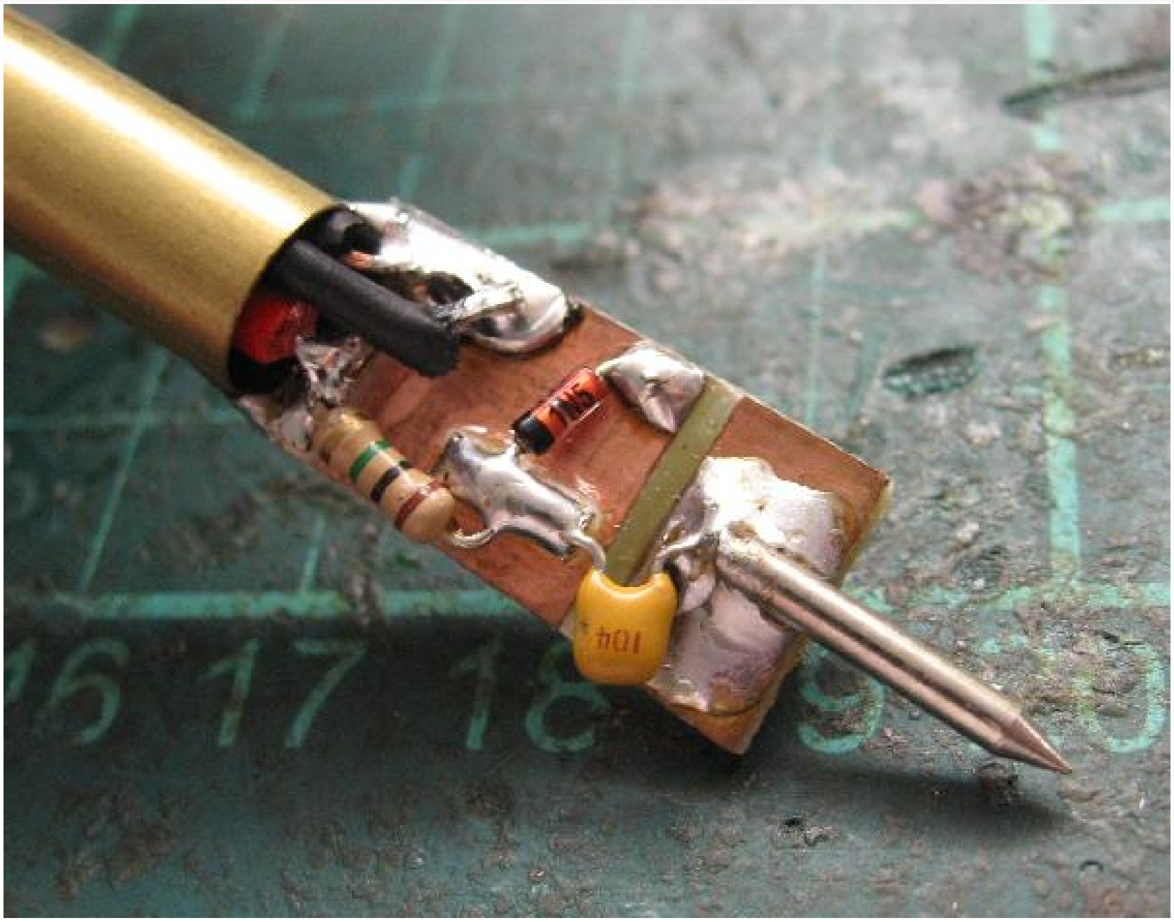
Being able to quickly measure RF power from -10 dBm to + 30dBm is extremely useful. This simple 50 Ohm load with inbuilt diode peak voltage detector fits the bill. Unfortunately it must be calibrated carefully and isn't direct-reading, but a simple table of Voltage or Current measured to delivered dBm can be constructed and kept near the unit.

I wrote a short program to generate a table of the Voltages, RMS, Peak and Peak-to-Peak that represent -20 dBm to +30 dBm. The formulae might be simple, but the table is useful for ball-parking, and was used to calibrate the meter at DC.

Calibration at DC isn't perfect, RF will read slightly differently as the dynamic properties of the diode vary. However it is extremely easy to just dial up DC voltages on your bench PSU and write down the corresponding reading on the multimeter.

If you use 75 Ohms more than you use 50 you might build and calibrate yours for that impedance. The load resistors will tend to dominate the frequency response, but the detector itself does affect the high-frequency return loss. The resistors and layout I used are only really suitable to low VHF, but for my immediate uses that is sufficient.

Build yourself a diode probe too (there is a 470p chip capacitor hidden under the wires).



Unlike the power meter the diode probe is designed to only load the circuit very lightly, measuring the peak RF voltage at the point under test. As the impedance of the particular point in question will vary it can only use used for relative measurements so there is little point calibrating it.

Notes

The diode is a 1N5711.

The 10 nF capacitor directly across the meter plugs is to prevent RF from upsetting the meter (smaller values using ceramic or chip caps might be more appropriate at higher frequencies). The budget meter show is actually very resistant to RF interference compared to some of my other multimeters, my old DSE Q-1418 did not like the RF at all once more than a few dBm was delivered. (Meter show is a Jaycar QM-1500, about $8 AUD. For the price you may as well just dedicate one to this service.)

The 1 KΩ resistor in series is to limit short-circuit currents to something that won't zap the diode. It is small enough to be effectively ignored when looking at the peak voltage with the high input resistance of a modern multimeter. It also allows you to use a current measurement instead, either with a mechanical VOM or bare meter movement, or with the multimeter. Your multimeter might work better in this mode. It can't hurt to produce a calibration for current too, so you can compare the measurement of voltage and current if something looks weird. (i.e. If you have your doubts about RF upsetting the meter due to an unexpected resonance.)

4 comments.

Attachments

title	type	size
RF Power Table Generator Source in PHP5	text/plain	1.082 kbytes

Ugly/Ground Plane Construction

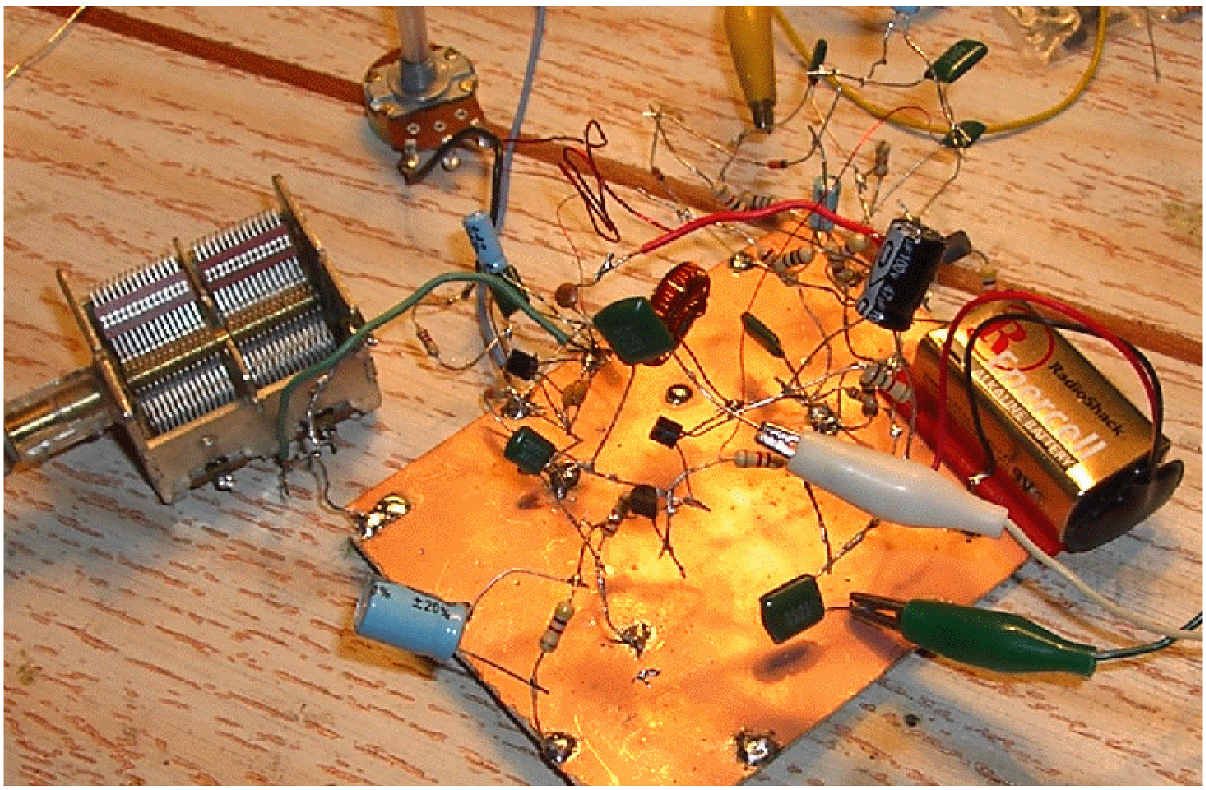
The Method I Use in Building My Simple Receivers

Oct. 7, 2006 by Rick Andersen, KE3IJ

Occasionally I get emails from readers who want to know how I build these simple radio receiver circuits on an "L-shaped chassis" without cutting and scoring the copper, what I mean by "L-shaped chassis," or "what's all this about 10 megohm resistors?", etc. I tend to forget that not everybody has done this before, and I usually take it for granted that the reader is an accomplished "basement-tinkerer" and should therefore be able to just look at a schematic diagram and then come up with his own layout and method of construction. Sorry if I have annoyed anyone -- that wasn't my intention.

When I first design a circuit, I make what a friend of mine used to refer to as a "spider" (or, "spider-web")-- basically just construct the circuit by soldering the components together, lead by lead, into a reasonable facsimile of the schematic (no chassis or pc board necessary-- the stiffness of the soldered leads themselves hold the "spider" circuit together). This method is quick, and allows me to modify things fairly easily. It also grows rather quickly into a "haywire monstrosity" if I allow it.

Sometimes I do use a piece of copper-clad pc board as a ground plane, even during the "spider" stage, as the photo below illustrates:



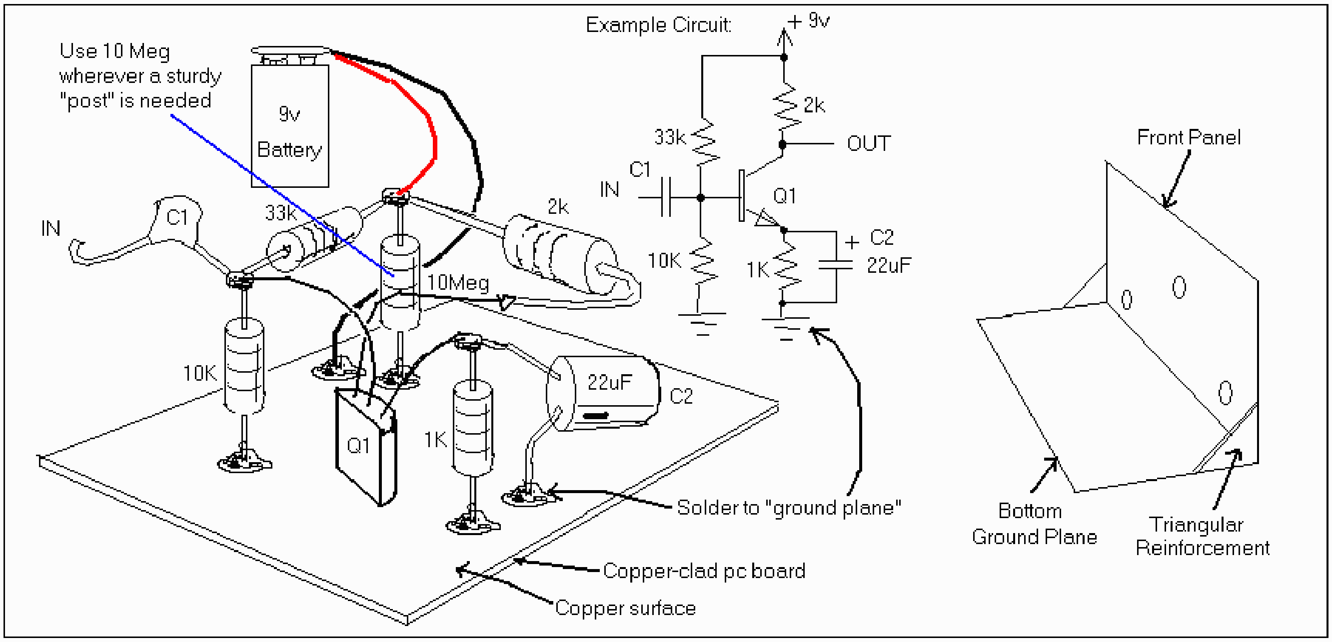
A "haywire" mess of my "AGC-80" Regen receiver in its early, experimental stage

To make things a bit clearer to you who have never built projects in this way before, I have attempted a free-hand diagram using Microsoft "Paint", which I converted to a .gif file and which you see below.

In the top-center of the diagram is the schematic for a simple common-emitter audio amplifier stage. The left side of the diagram illustrates how one might translate that schematic into an actual circuit on the copper-clad pc board. At right is a diagram of the "L-shaped Chassis." This is the style in which I build most of my circuits.

Basically, I use 2 pieces of 5x7 inch copper-clad pc board, available in the USA at **Radio Shack** [free plug]. One piece lies flat (the bottom piece), which is what I have shown in the diagram. I build my circuit on this bottom piece, using the copper floor as my ground connections ("ground plane"). Any resistors, caps, etc., that go to ground in the schematic, are literally soldered to this bottom ground plane and stood upright. At their top ends, the rest of the circuit is soldered, suspended up above the ground plane. Anywhere that I think I need some mechanical stability, I use a vertical 10 Megohm resistor, which acts to prop up and support the rest of the wiring above the ground plane. For most of the circuits I build, 10 Megohms is much higher a resistance value than any of the resistors in the circuit itself; therefore, the circuit pretty much ignores the 10M "posts", electrically, and they remain simply a mechanical "standoff insulator". The 2nd piece of copper clad board is drilled for switches, potentiometers, tuning caps, and earphone jacks, etc., and then is soldered at right

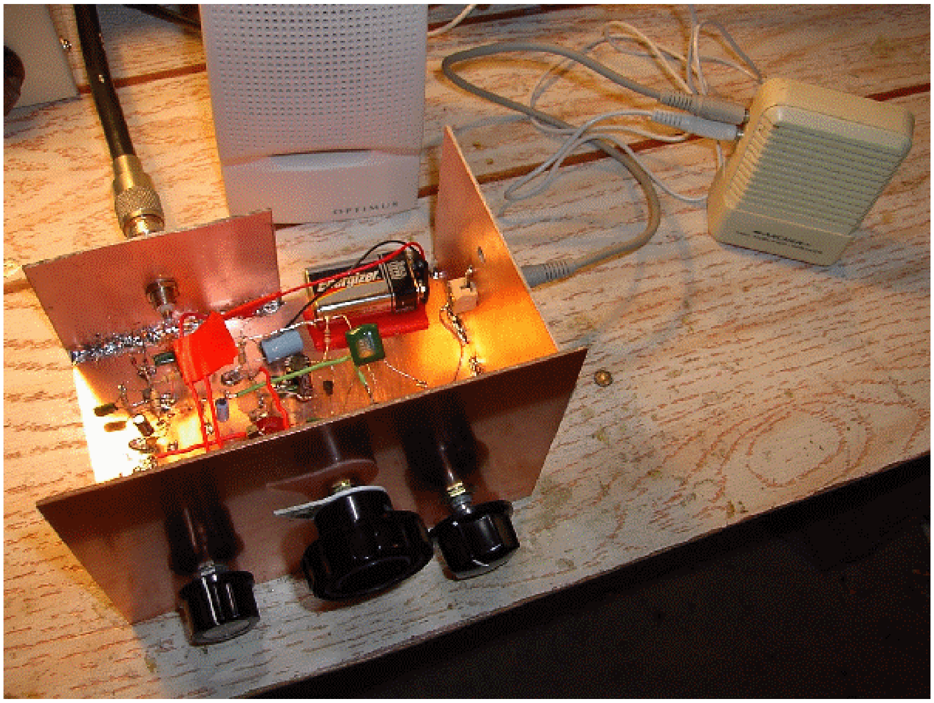
angles to the flat bottom piece, making an "L-shaped chassis". It also helps to solder triangular pieces of copper-clad board as mechanical braces, at the corners where the front panel is soldered to the bottom ground plane.



Below is a photo of my 2006 creation, the "AGC-80", a Regen receiver for the 80 Meter ham band with audio-derived AGC. There's an article on this receiver elsewhere on this website; meanwhile, notice that it is built in the same way outlined above-- an "L-shaped" chassis made of a bottom piece of copper-clad board, soldered to a vertical piece of the same kind of board which is the front panel. [I also added a back wall to hold the antenna jack, and a right wall to hold the audio output jack, as well as a triangular reinforcement piece of copper-clad, at bottom-left between the front panel and bottom piece, although you can't see it in this photo.]

To the right of the AGC-80 is the infamous Radio Shack/Archer little beige Amplified Speaker that I'm always mentioning. I may knock Radio Shack for other reasons [for example, that they have pretty much left us hobbyists behind, and have become just another consumer electronics store] but I will always say good things about their little $12.95 beige-colored Amplified Speaker. It works like a charm for the kind of projects I build. I also run an audio cable out of the Radio Shack amp to a bigger speaker, for better-quality sound-- in the photo you can see a white "Optimus" computer speaker pressed into this service. While the Radio Shack's speaker does a fine job, the Optimus sounds quite a bit louder and way nicer. Of course, you may argue that a *real* Electronics Geek rolls his *own* audio amp rather than rely on a commercially-made, external one. Well, I'm often too impatient to build the audio power amp myself, after having spent hours or days getting the RF part of the radio to work the way I want. Also, homemade audio amps tend to oscillate (squeal, motorboat, howl) in mysterious ways once lovingly installed on the same circuit board as the RF circuitry.... After a while one grows tired of trying 50 ways to make it happy, and would rather just hook up an Amplified Speaker and be done with it.

To each his own.



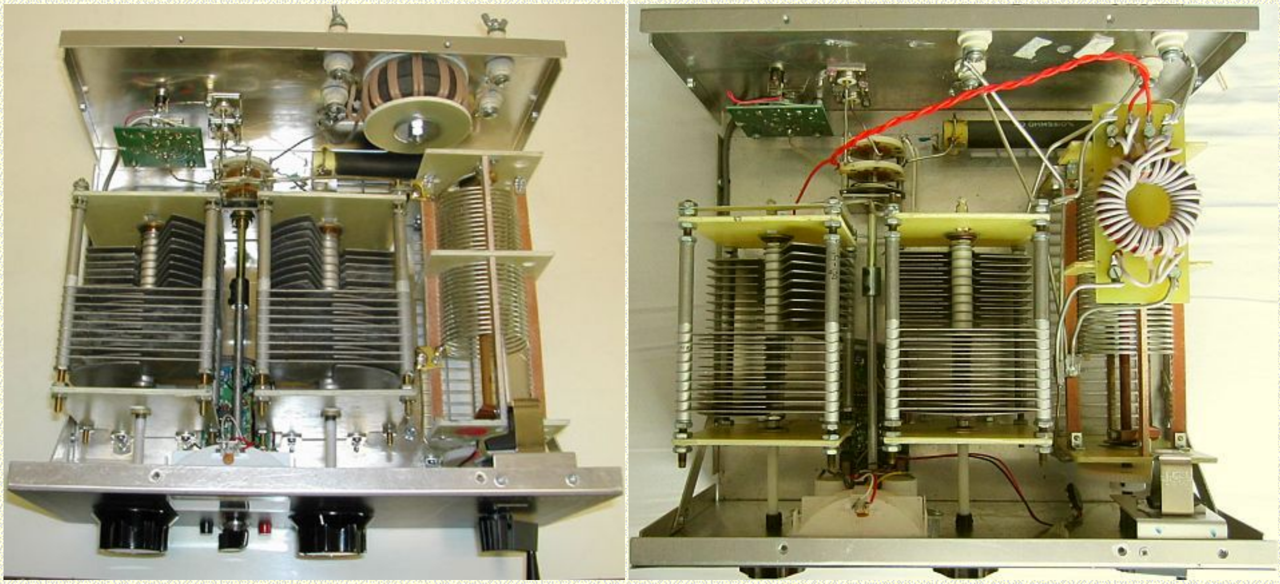
Please realize that you don't have to follow this method of construction (usually called "Ugly Construction" by hams), but I would advise you to make sure there is some equivalent of a copper ground plane in most of your radio projects... it helps to shield the circuit from outside influence (particularly when connected to earth ground) and contributes to stability.

I hope this has helped to give you a little better idea of the methods I use!
73 de Rick, KE3IJ

[Back](#)

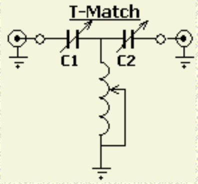
MFJ-989D CONVERSION TO S-MATCH

UP 07-sep-2016 Final installation.



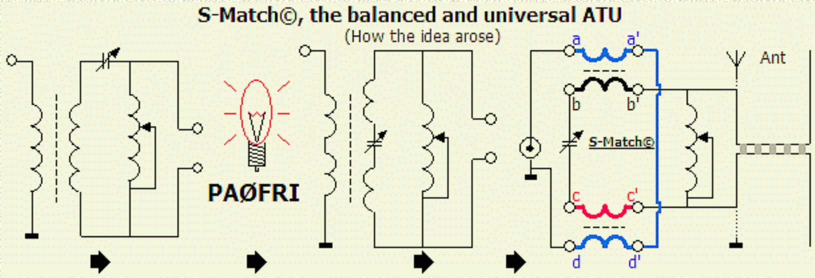
MFJ-989D conversion to symmetrical S-Match ATU.

INTRODUCTION

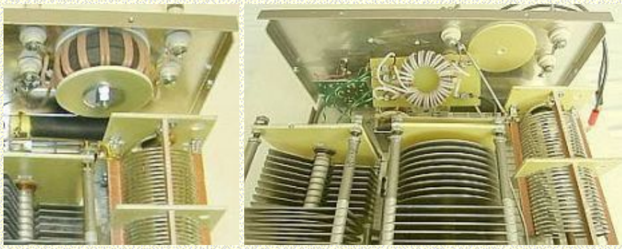


A MFJ-989D Versa Tuner is an A-symmetrical antenna tuner equipped with a T-match (T-network) system. For matching a symmetrical antenna system, a current balun can be switched on. While such a configuration can work well with some ladder line antennas it is not always the best system. A true symmetrical antenna tuner is an appropriate way.

A MFJ-989D with bugs and missing current balun was available to make "something else". A great opportunity to examine whether it was suitable for conversion into a symmetrical system. Because the two variable capacitors were already standard assembled insulated from the base cover, this incomplete device was chosen for conversion to a S-Match tuner.



How the idea for a S-Match developed

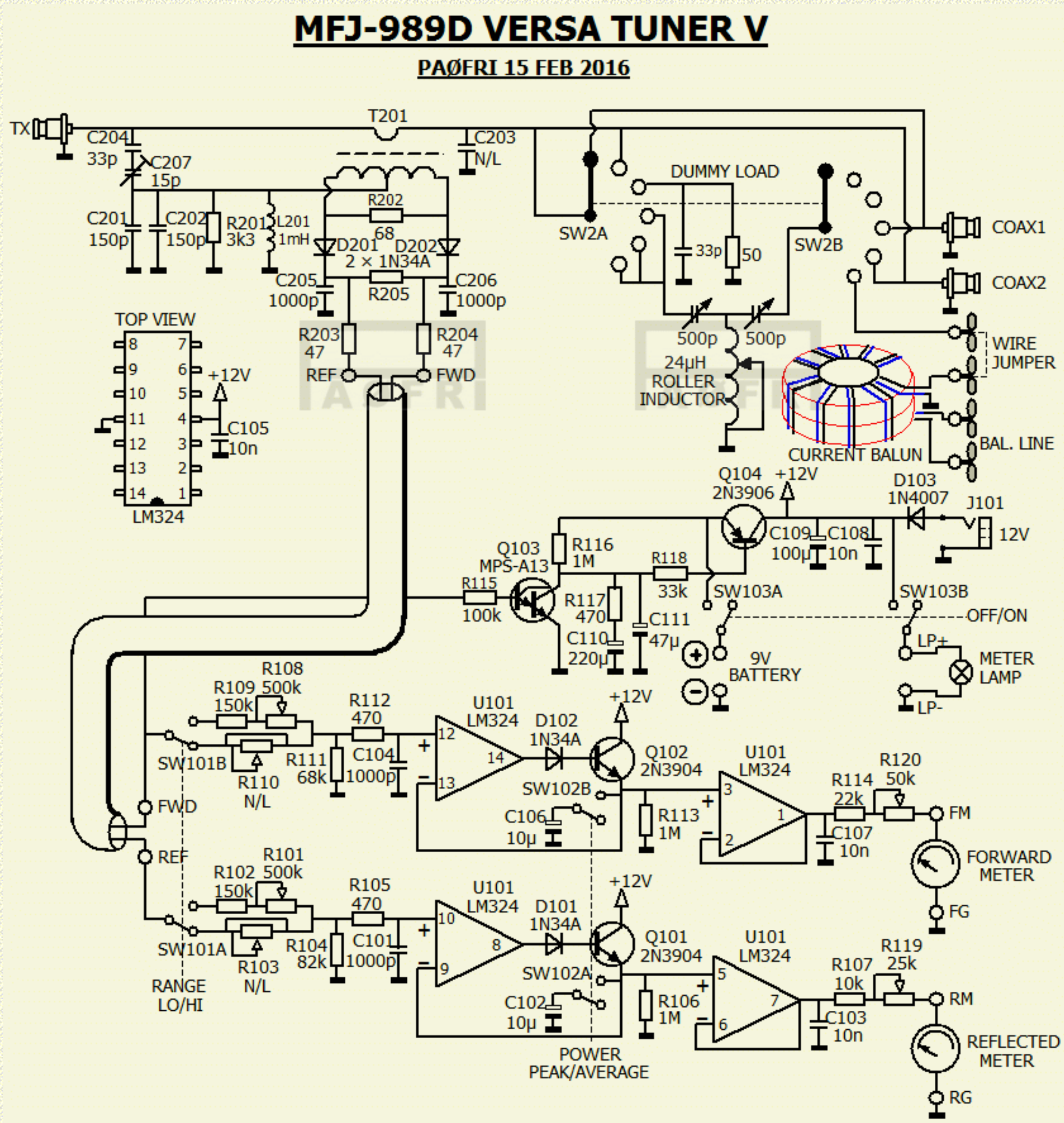


Test if a MFJ-989D Versa V tuner is suitable for conversion to a S-Match antenna system tuner.

An experiment with a provisionally-mounted balun revealed that a modification could be carried out.

SCHEMATIC

The schematic of a MFJ-989D looks like this:

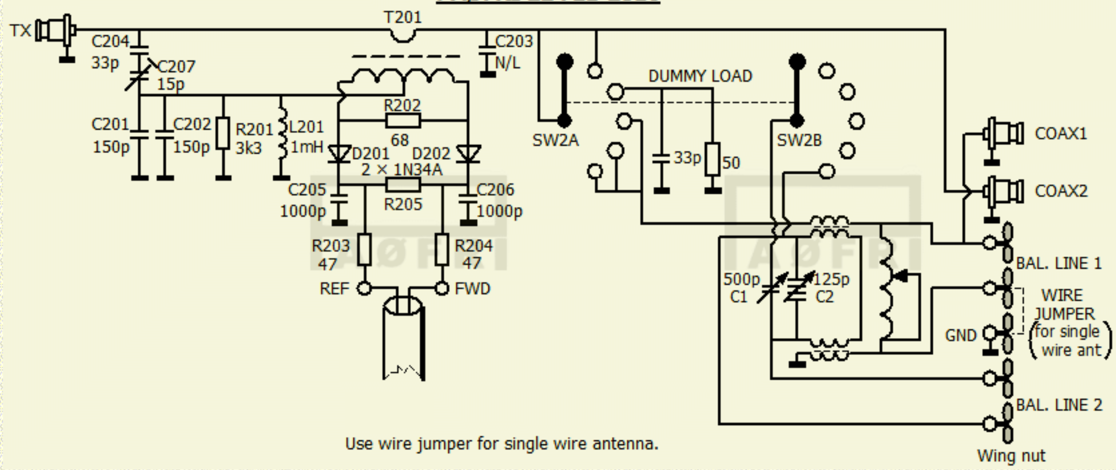


MFJ-989D CONVERSION TO S-MATCH

The part converted to S-Match, looks like this:

MFJ-989D VERSA TUNER V conversion to S-Match

PAØFRI 22 FEB 2016

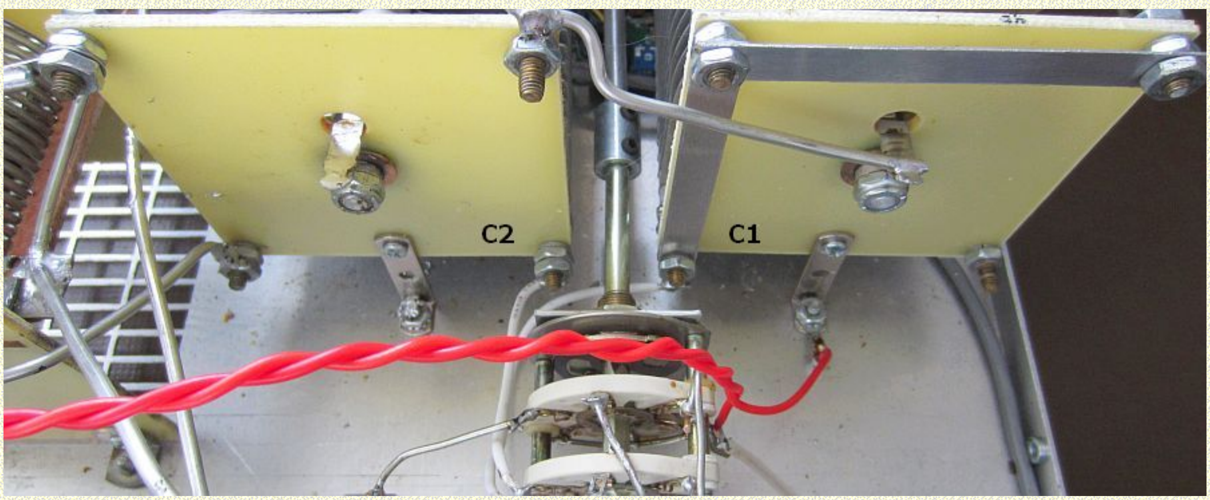


VARIABLE CAPACITORS

In a S-Match not only the roller inductor determines the tuning range but also is the minimum and maximum capacitance of a variable capacitor.

In this MFJ-989D each variable capacitor is maximum 2 × 250 pF and minimum 2 × 22.5 pF. With an antenna on a particular band it is possible that maximum capacitance of a capacitor is too little or minimum capacitance is too large to match the system. By changing the wiring of SW2, one can connect the first capacitor (C_1) in parallel with the second capacitor (C_2) without additional switch.

Assemble two sections of C2 in series so that you have access to a minimum capacitance of 22.5 ÷ 2 = 11.25 pF and a maximum of 500 + (250 ÷ 2) = 625 pF. This is sufficient for matching many antenna systems but sometimes it is a 3-knobs in stead of a 2-knobs tuner. In general C2 is used for 10-30 m and for 40-160 m C1 is connected in parallel.



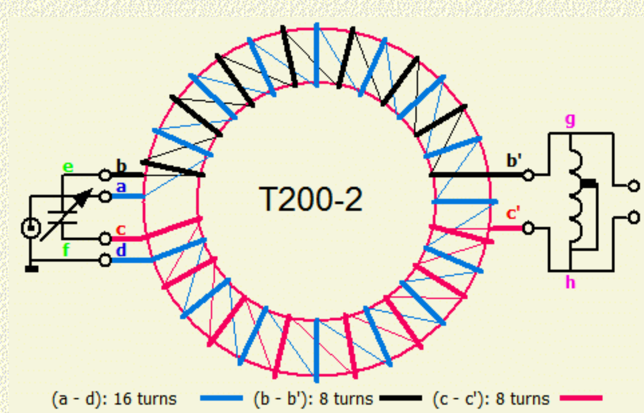
Sections are connected in series C: 11.25 - 125 pF. C1 (= 500 pF) can be connected in parallel onto C2 with the switch.

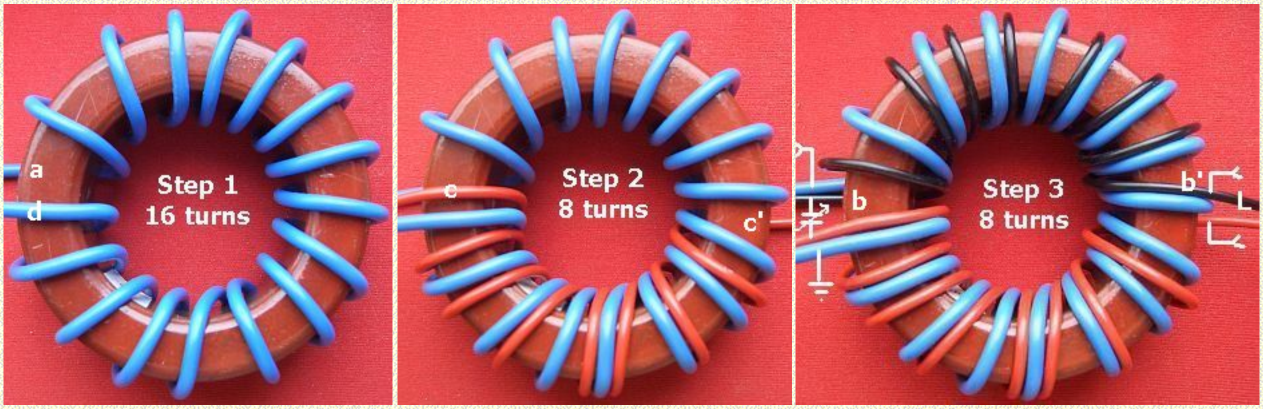
BALUN

The balun is made with Teflon insulated wire on a red T200-2 toroid (larger type as well). Apply 16 turns (a - d) and two 8 tuns (b - b ', c - c').

The connections of capacitor (#e and #f) and of roller inductor (#g and #h) are each connected with two wires or ribbon line to one of the porcelain antenna posts at the back cover.

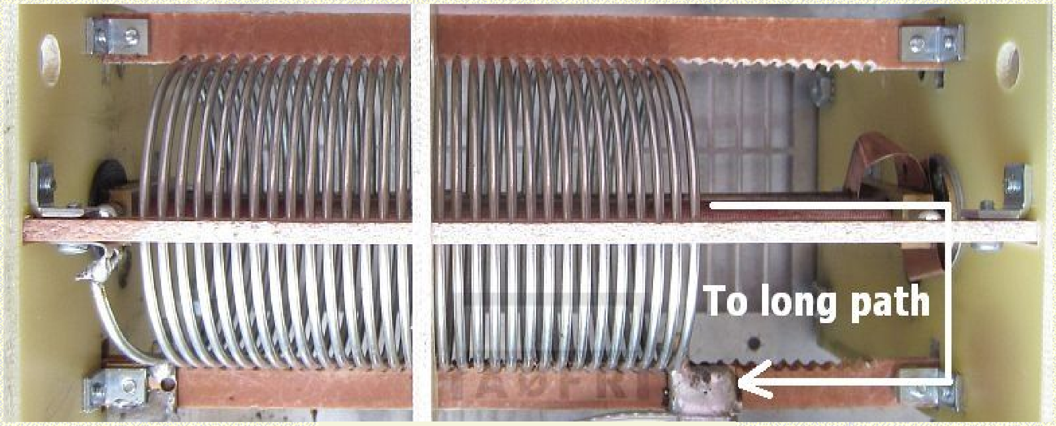
Applying windings and connecting to other components of the tuner turns out to be a problem for some people. If something is done incorrect, the toroid core can become hot. The following step by step method will hopefully clarify the construction.

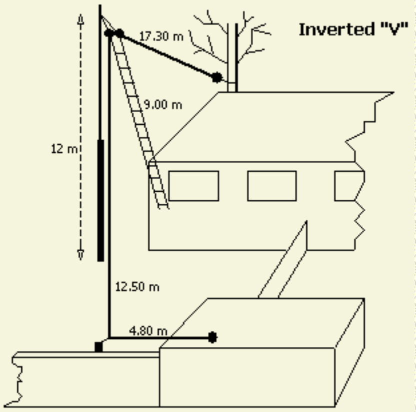




Sequence of windings. Left side connections: blew = input, red & black = capacitor; right side connections: red & black = roller conductor.

ROLLER INDUCTOR

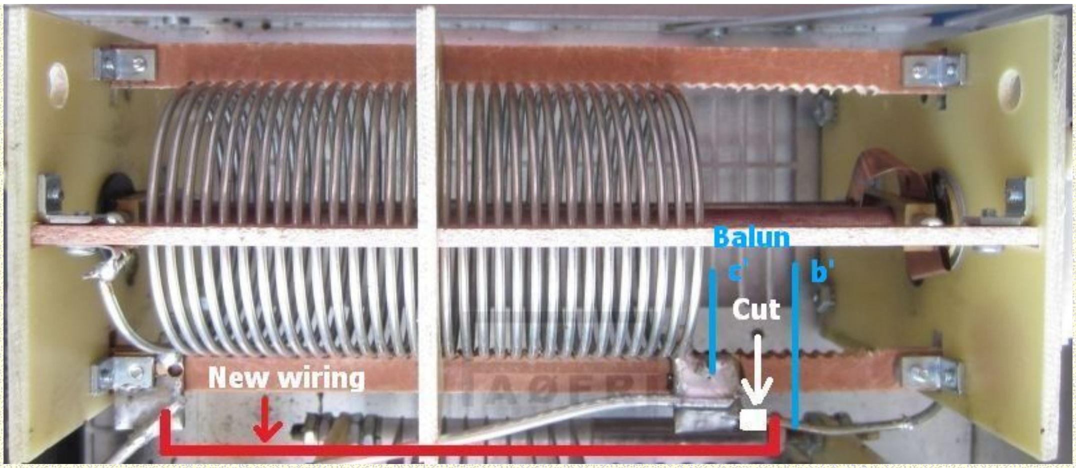




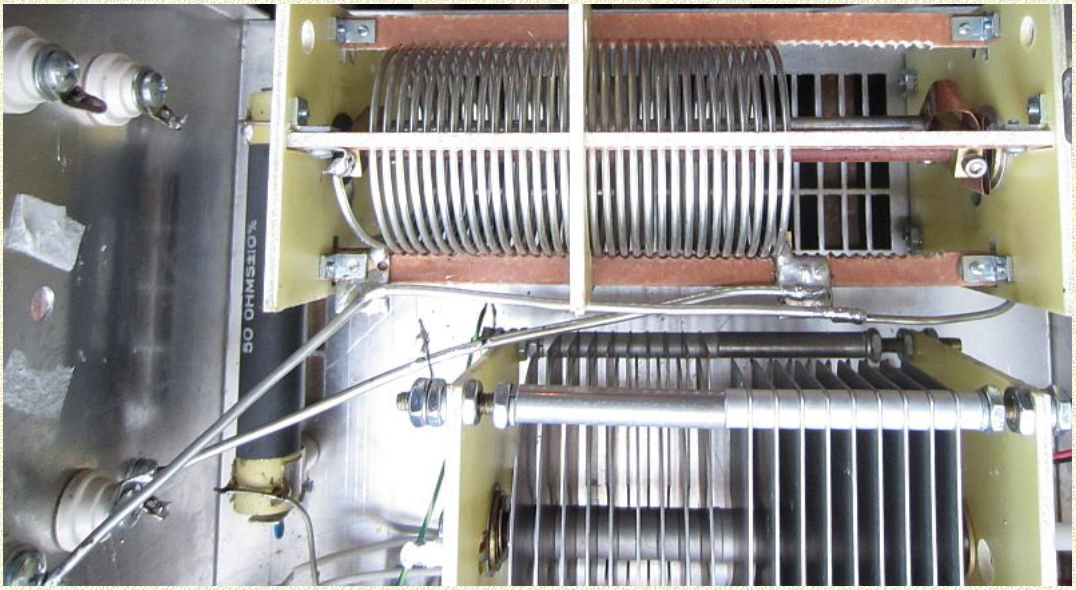
Manufacturer advertises with superlatives about the roller inductor and the tuner would be suitable for 1500 watts. However the wire gauge of the inductor is too thin for that the power and it is only valid if the antenna system has a very favorable impedance.

My antenna is only 2 × 17.30 m as inverted V. If the MFJ-989D is tuned on 160 m, the roller inductor is getting hot with a 800 Watt carrier during 2 minutes! In my view, 300 W continuous power and 1 kW PEP power is more to the truth for a MFJ-989D! Perhaps is that the reason this tuner is remarkably often offered 2ndhand if MFJ-989D is searched with Google. An American ham was apparently not happy with the roller inductor coil because he replaced it by a type with thicker wire.

Furthermore the track from slide contact to the end of the roller inductor is to long. This is mainly due to the gap between coil and faceplate. Obvious the inductor (fig») was designed for a different application and manufacturer has removed a large number of turns. The long path is mainly affecting the 10 m band where wiring is the major part of the "coil"! As a result, it is often difficult or impossible to tune the highest amateur bands. If it succeeds efficiency is not the best. Onfortunately the rotary inductor has to be turned anti-clockwise to increase inductance, which is an unusual method. A 180º assembly would have been better in all respects.



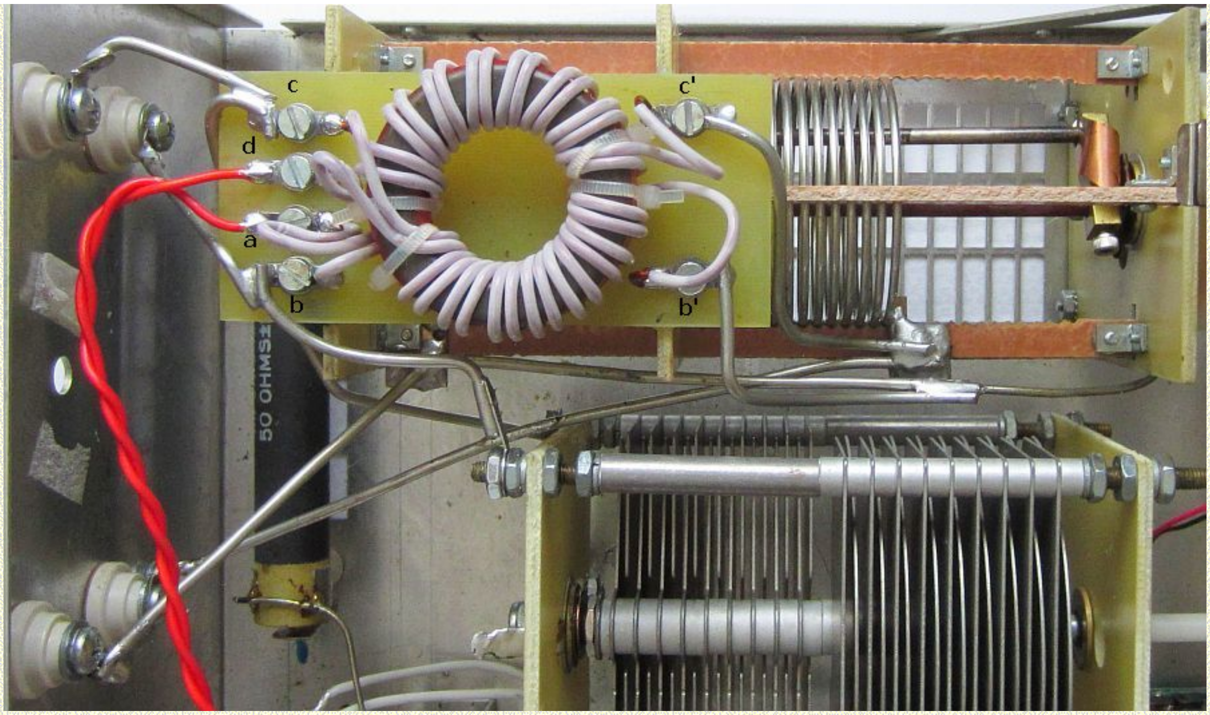
Cut or desolder wire at the arrow and extend (= red wire) to the left side of the inductor.



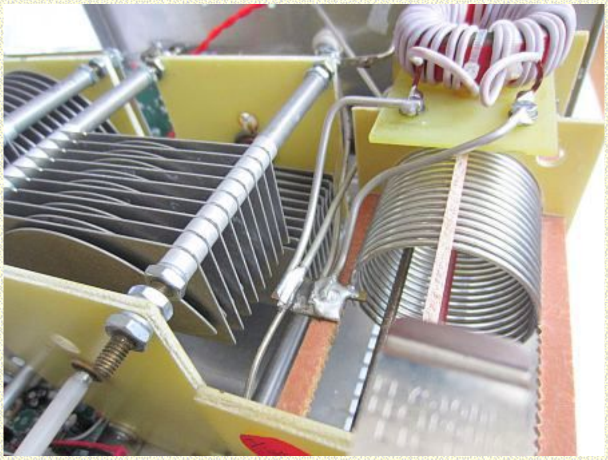
Wiring changed.

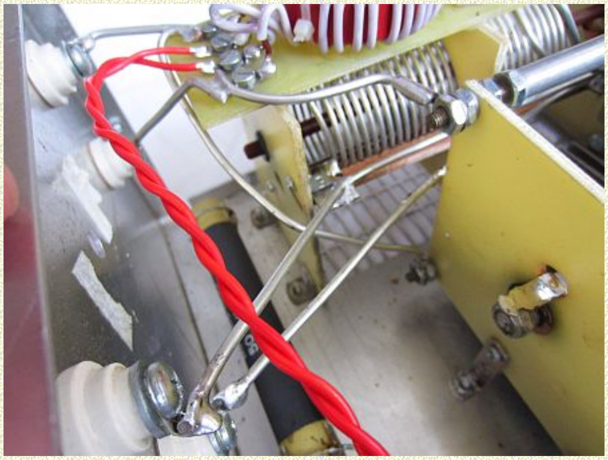
Fortunately, an improvement is possible. Disconnect the wiper wire to the inductor and extend the wire as it is red colored in the image. Now there is more "coil" and less wiring. As additional adventage the roller inductor must be turned clockwise for increased inductance, e.g. counter works correct.

FINAL ASSEMBLY



The final assembly with the shortest possible leads to other components.

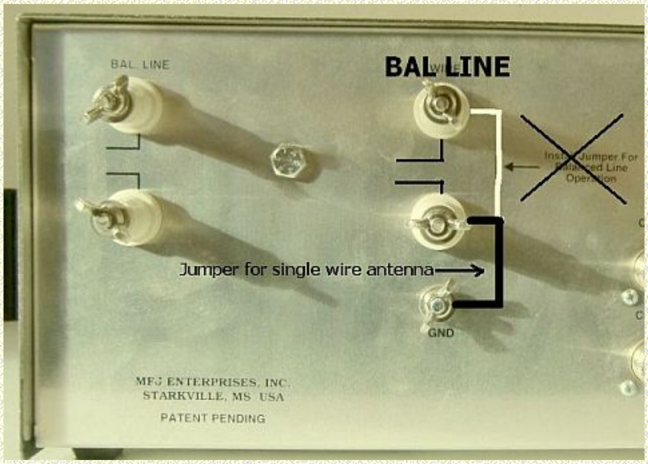




For mounting the balun enough space was above the roller inductor with sufficient distance to the metal top cover. Using a glue gun the copper-free epoxy plate was fastened on the upright plates of the inductor. That in itself is already strong enough, but the 6 mm² mounting wires are extra securing. The foregoing ensures that leads to other components, is kept as short as possible.

The balun is connected as is highlighted in one of above images; see also #b' and #c' below.

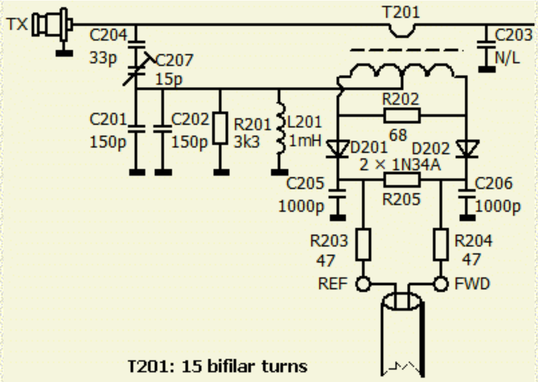
TWO BALANCE LINE OUTPUTS

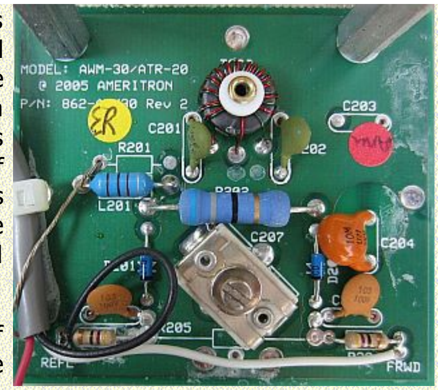


The converted tuner can match coaxial and ladder line antenna systems. For optimum performance the line can be connected in parallel with the roller inductor or across capacitor C2. Both systems have advantages and disadvantages, but parallel at the coil is most in vogue. Try which connection delivers maximum antenna current.

To feed single-wire antennas one of the wire terminal post is connected to the ground terminal post at the back cover.

SWR CIRCUIT





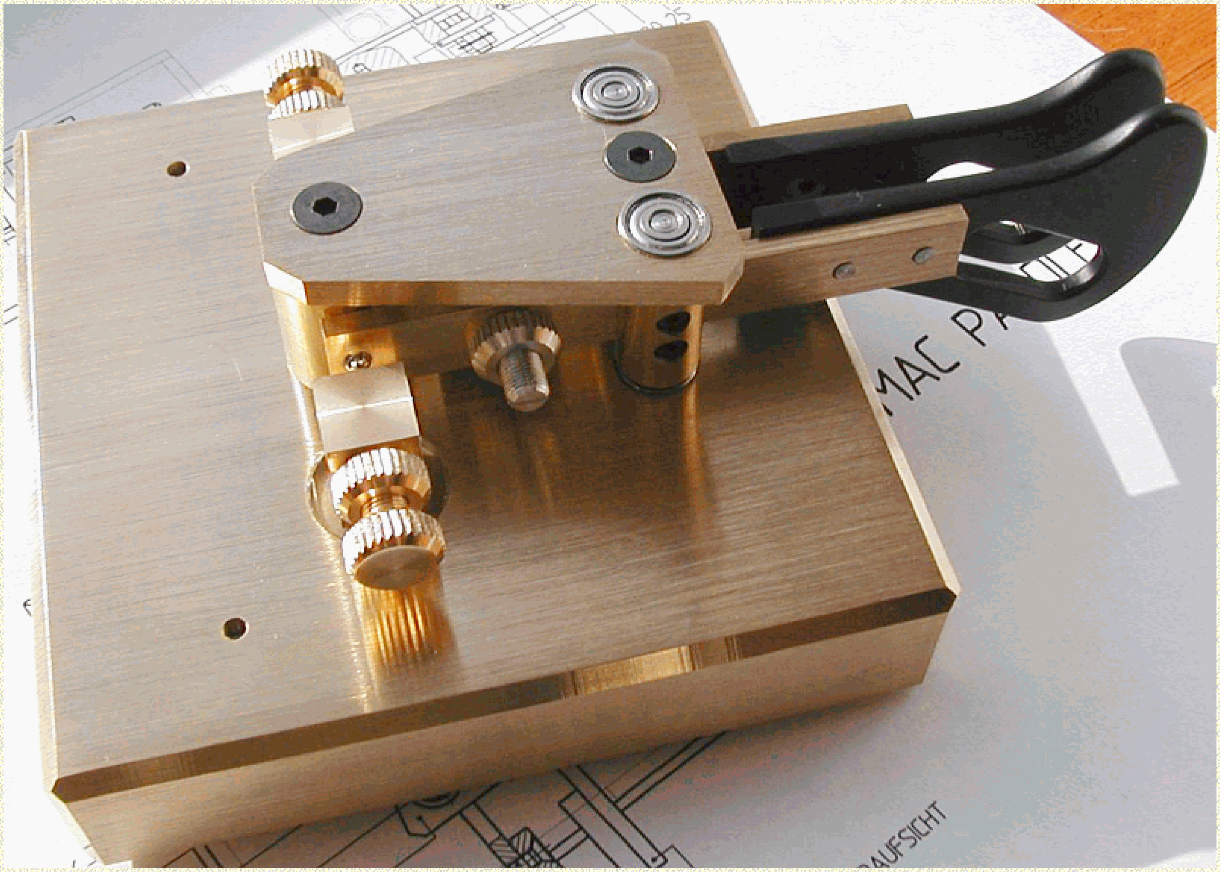
The SWR circuit of some 2[nd]hand tuners are damaged or defective. MFJ does not sell the SWR PCB, so some DIY has to be done. The former owner of this Versa Tuner is a deceased ham who was only working on some modifications of the tuning section. As I see the PCB he has nothing changed but it appears that the factory did not assemble R201, R205 and C203.

One owner had a burned PCB and parts of toroid T201 were missing so that the number of turns could not be determined. Probably a ferrite toroid of mix 43 such as FT#-43 with 15 bifilar turns can be a good substitute.

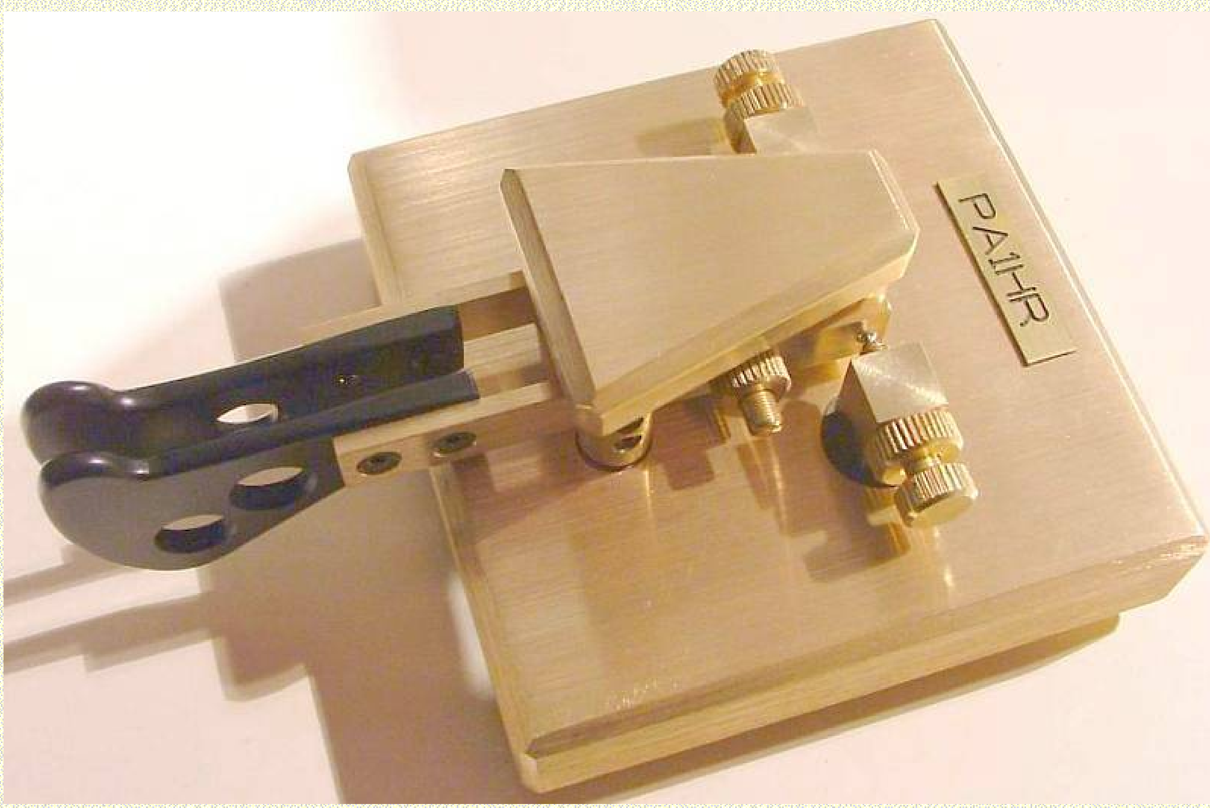
Ater an overload germanium diodes D201 and D202 (1N34A) can be damaged, e.g. short-circuited or partially conductive. With some searching on the internet suitable germanium diodes can be found but if not use a Schottky diode (BAT85 for example). A disadventage is that the scale is no longer reliable, only SWR = 1 is real.

ON4MAC's Paddle Keyers

(MacPaddle, magnetic system)



Prototype MacPaddle, 1.845 kg, base 10 × 10 cm



Paddle for PA1HR

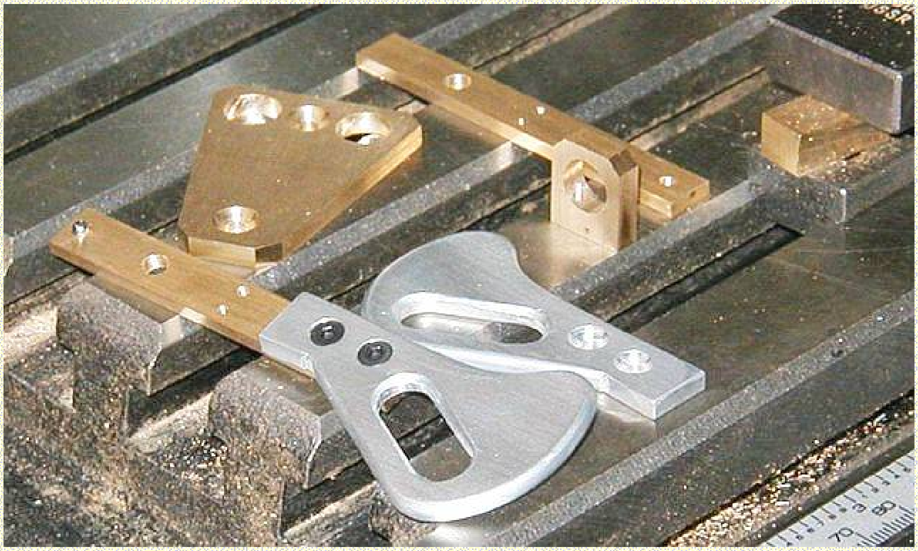
ON4MAC

When Michel ON4MAC decided to try CW, he looked around and picked what he thought were good ingredients for a paddle and later he decided to start out by building a decent paddle for himself. The result is an outstanding key with many constructive elements that can be found only in the best modern paddles: magnetic returns, precision ball bearings, low moving mass. It has many components of a top notch key and the unmistakable handwriting of a master craftsman. BTW it is a beautiful object in any shack!

The brass is not protected, so, like the Kent (fig»), you have to give it some loving care. The feel is very smooth, which is the result of the magnetic system that is used insted of a spring. The magnetic return force can be adjusted precisely, and, in combination with the sealed ball bearings, it allows very light settings with excellent responsiveness. You would be hard pressed to find a better performing key at any price. Michel produces these keys slowly and carefully by hand and, of course, he doesn't have a stock pile of them. So you may have to wait a bit if you want to treat yourself to one, but it's worth it. When you see this key in photos, and you know a bit about paddles, your first reaction might be: It is an excellent paddle, made by a real perfectionist. When you put them side by side with other keyers in reality, however, other makes like a light- weight in comparison, and the ON4MAC surpasses it in several other aspects. too. The finish is flawless.

In actual operation it has to be counted among the truly great paddles regardless of price: absolute precision up to the highest speeds and the closest contact spacing, stable and highly precise adjustments, more than enough mass to keep it rock steady on your table.

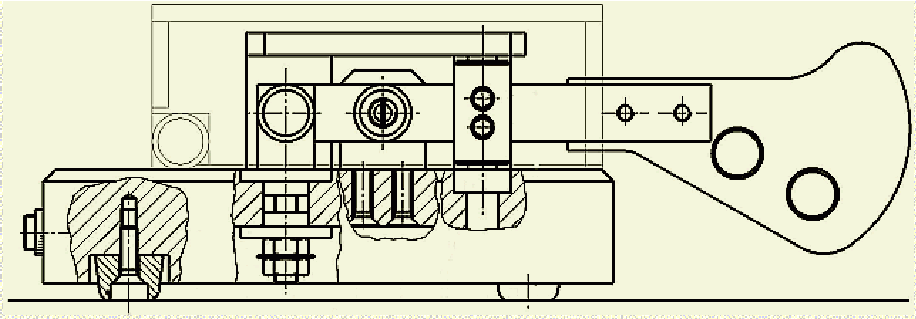
You may have to curb your enthusiasm a little if you want to rush out to get yourself a present. Michel has built only a handful of them yet, painstakingly one at a time, and he's not too sure yet how much time he can dedicate to building more of them. Michel is a very kind person and always listening to users to make improvements on his straight and paddle keys and willing to change things. However his email address is on4mac@amsat.org and I have never heard him refuse a polite request to be put into his still growing queue.

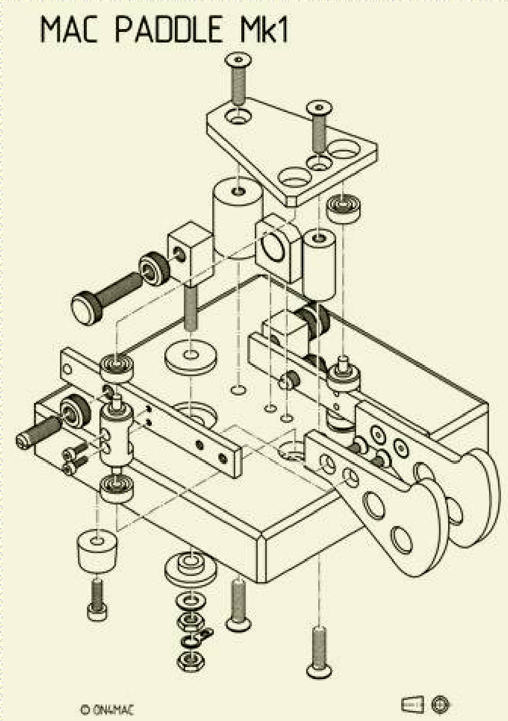


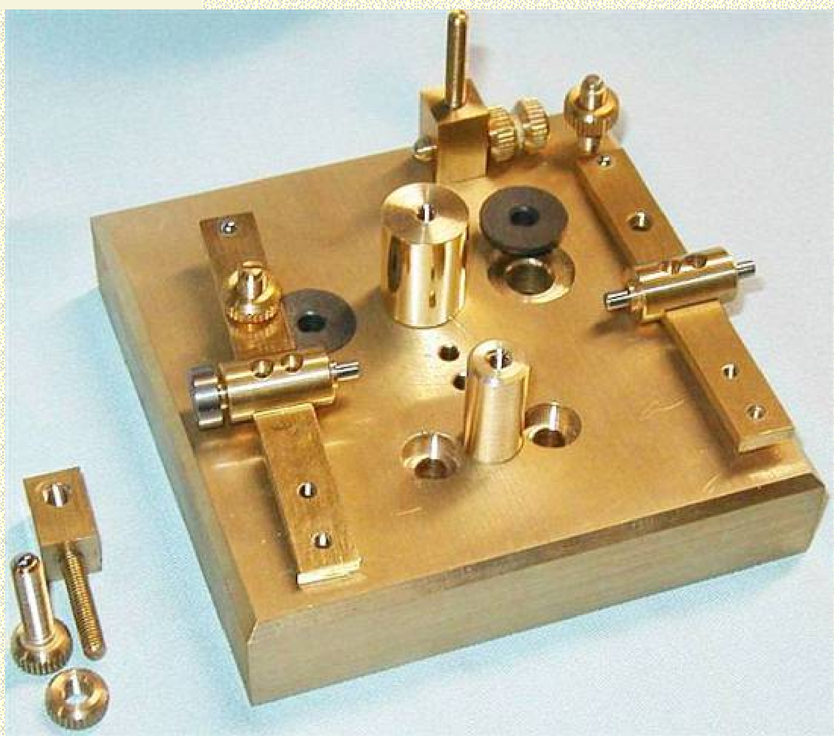
Craftsmanship

ON4MAC's PADDLE KEYERS

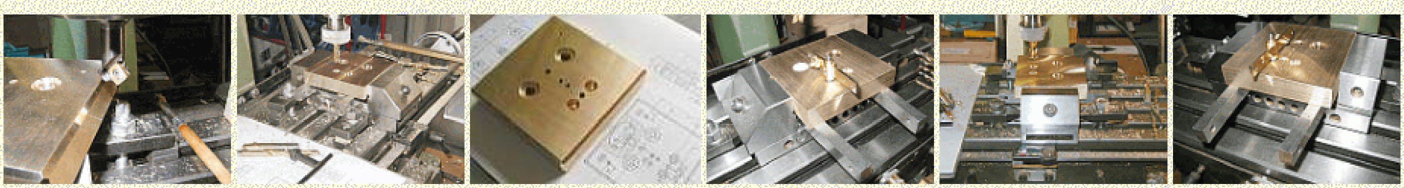
Michel has no company, but makes keys and paddles for pleasure.



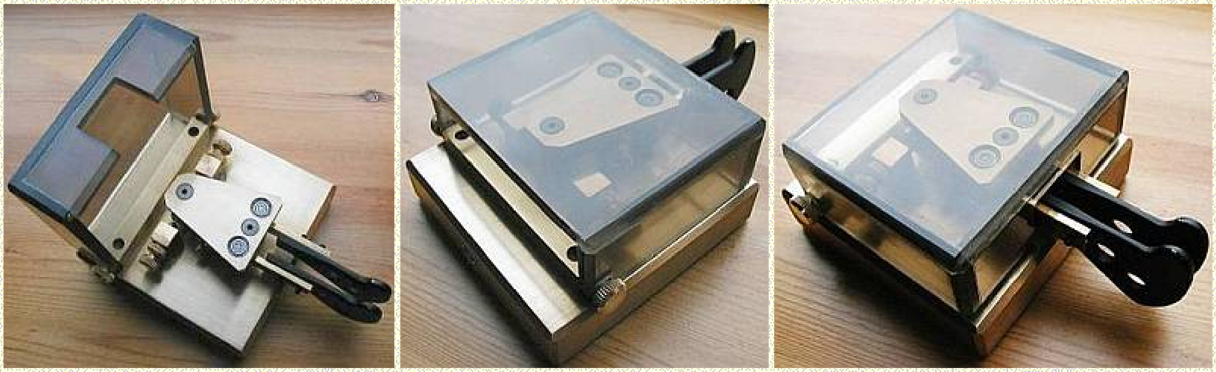




Assembling a rpiece of cake job?

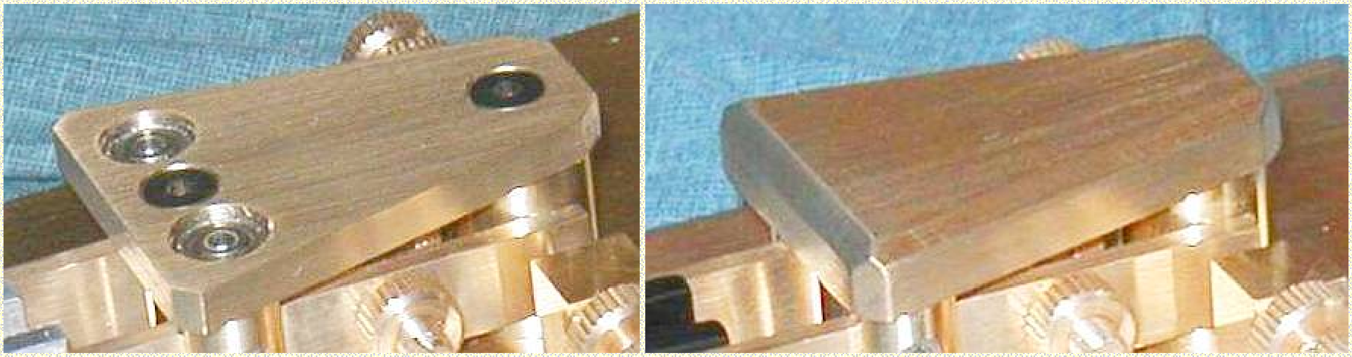


Click for some pictures of the production process



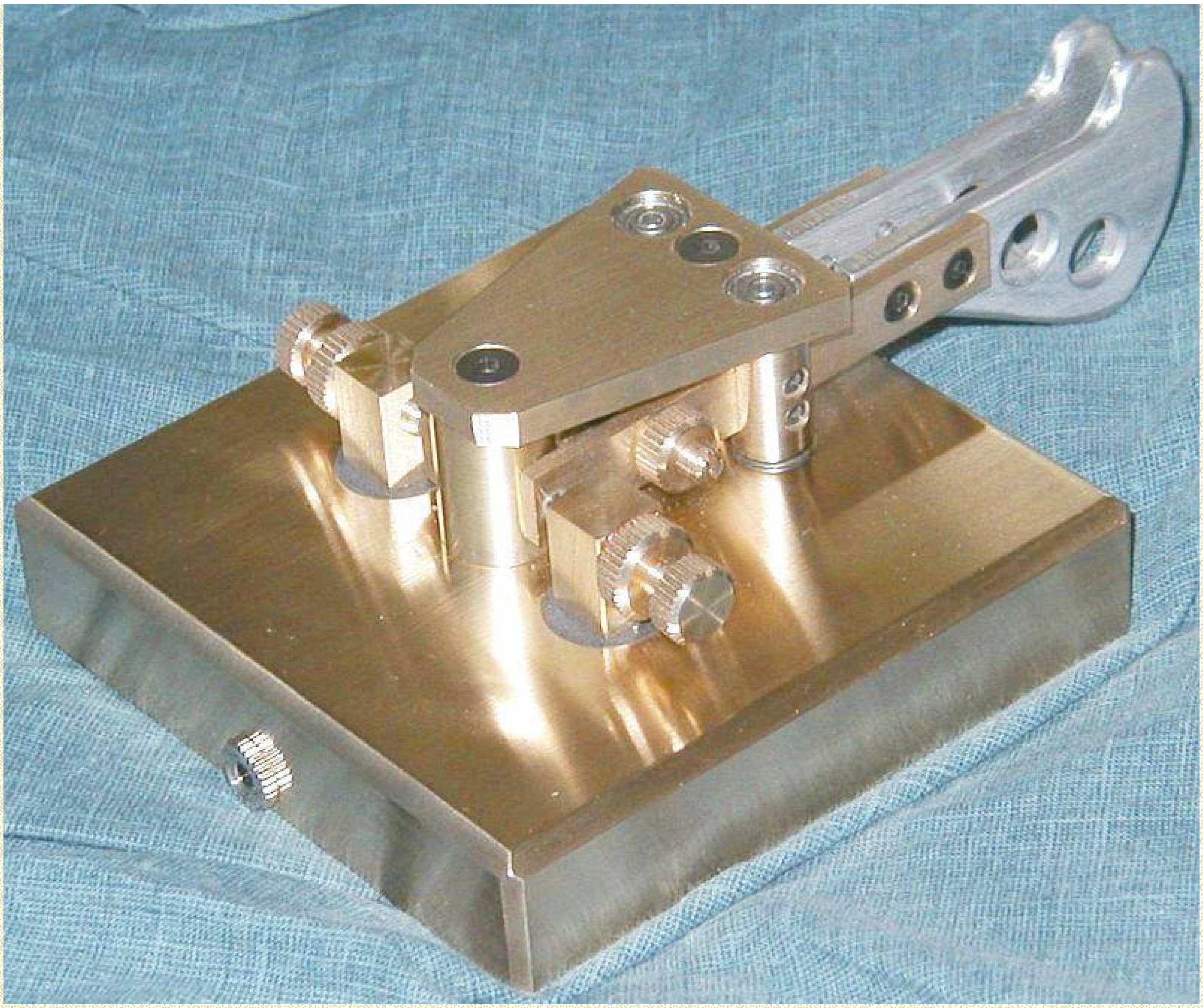
A cover is one of the options

Some model finger pieces

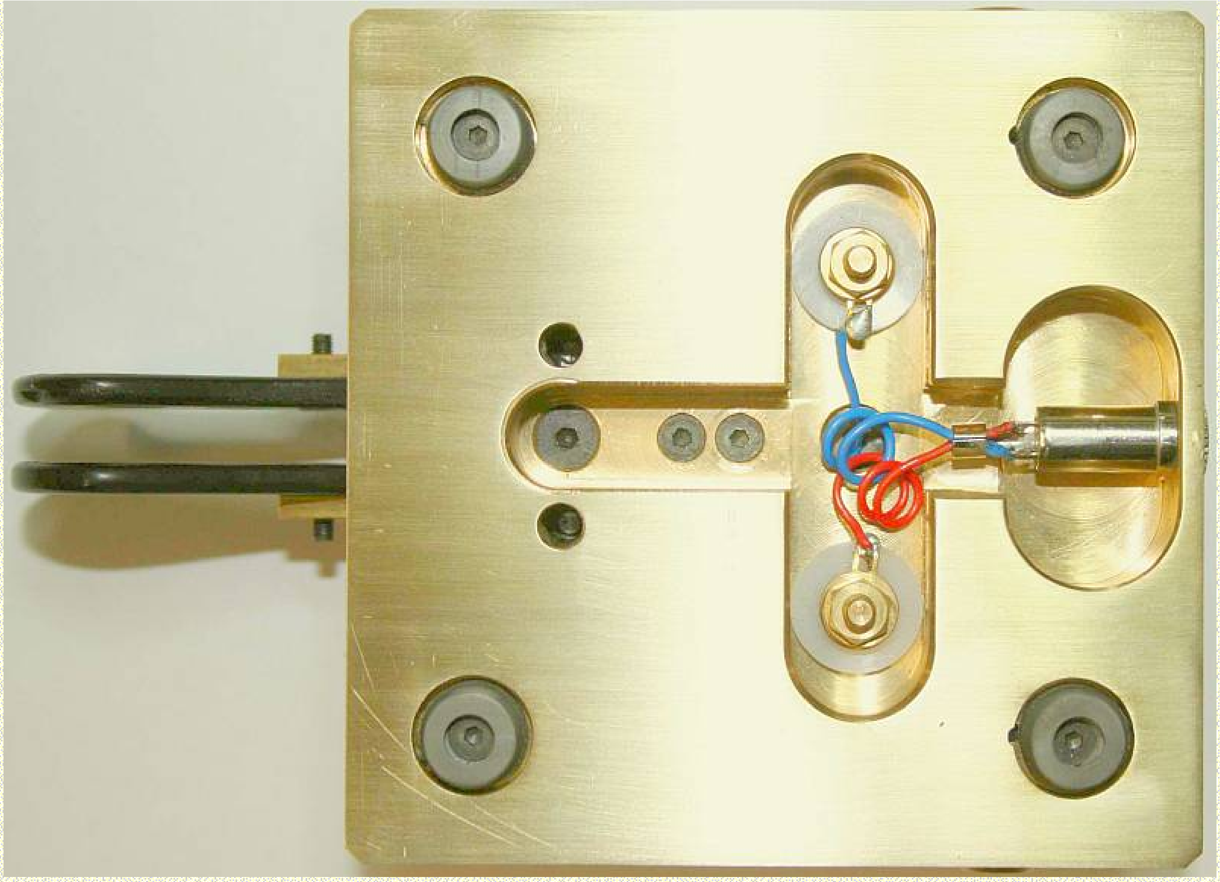


A matter of taste: visuable or covered ball bearings

Type "Hans" PA1HR, watch the finishing



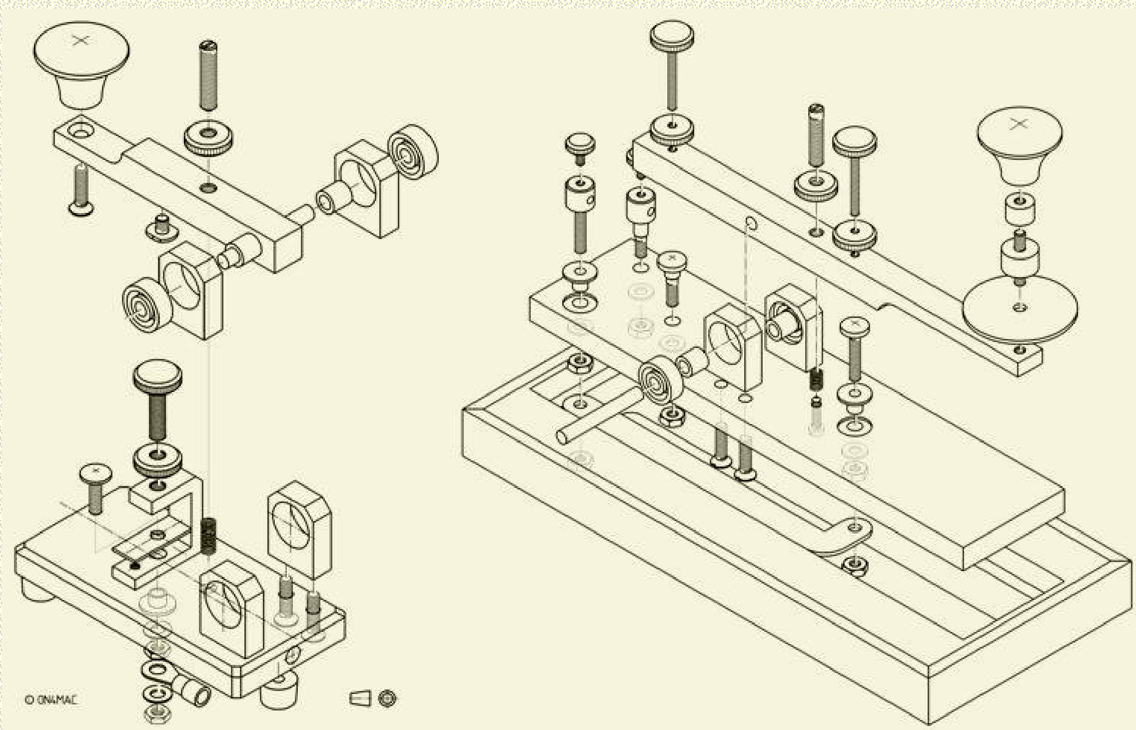
Type "Ward", all keyers are fitted with a plug

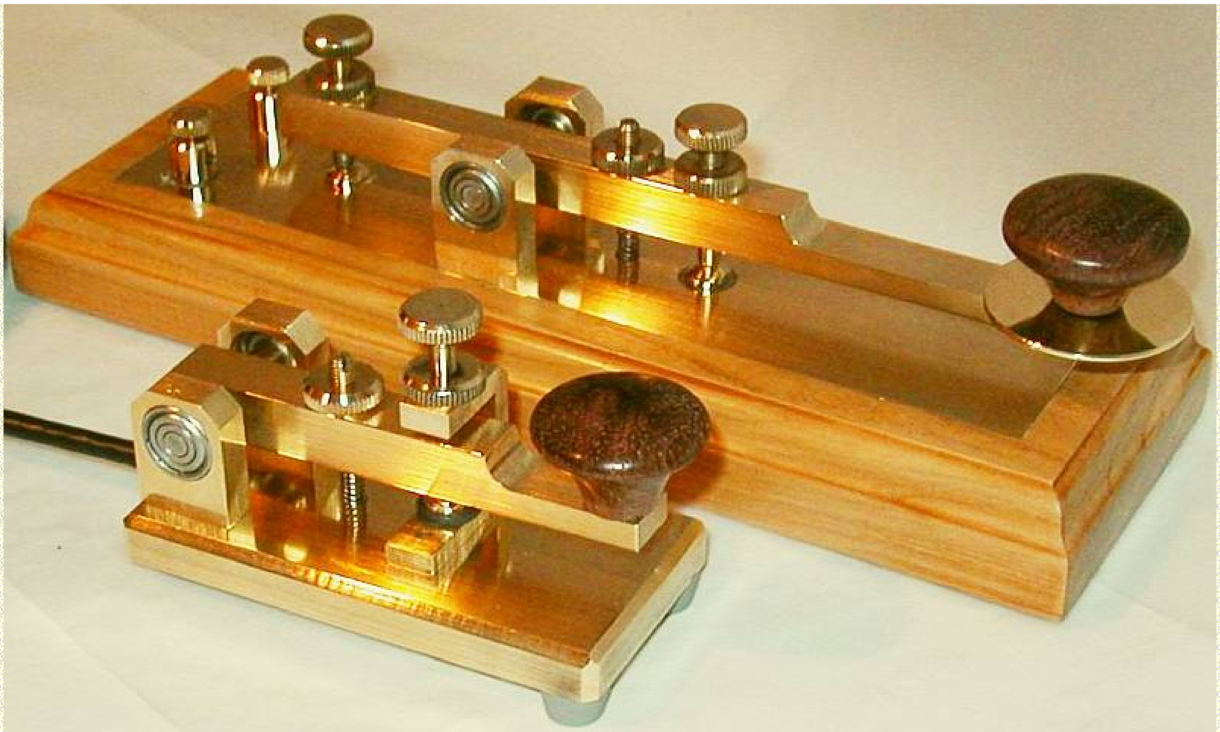


Even the base is a beauty

STRAIGHT KEYS

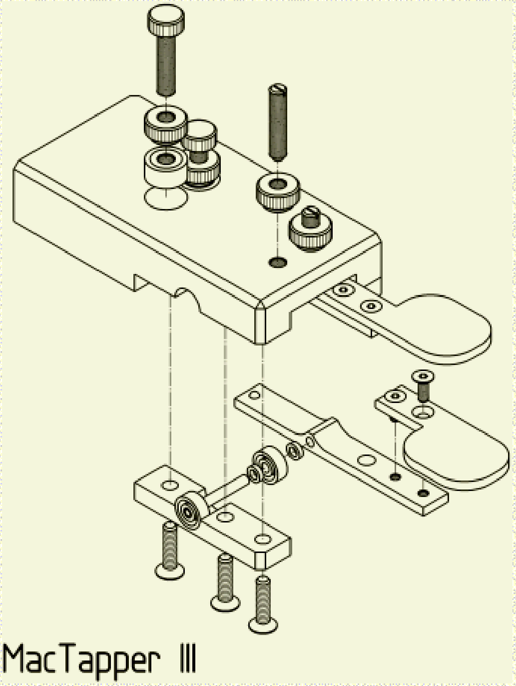
More craftsmanship: straight keyers.





Large and small key, respective: 250 × 85mm, 1.49 kg and 100 × 50 mm, 0.620 kg

TAPPER KEY



Mac Tapper type "Feri"

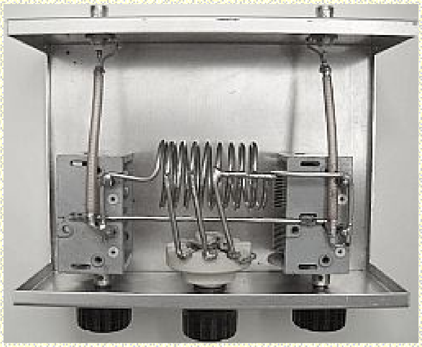
START WITH DIY PADDLE

Piet PE1ADY's DIY paddle keyer to test his "feeling" for this sytem of Morse code.

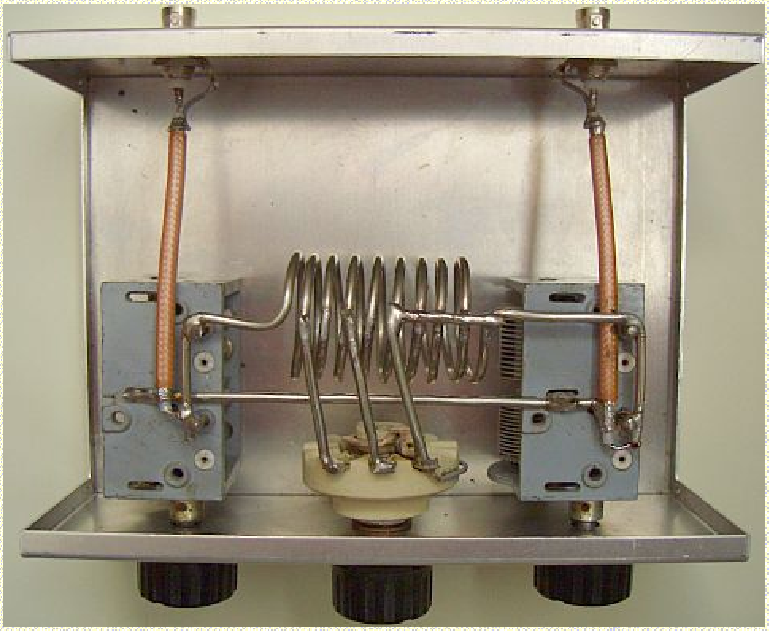
«Back
AØFR

Pi-filter ATU for resonant Yagi and Vertical antennas.

UPDATE **14 mar 2014.**

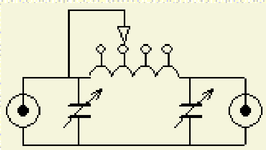


INTRODCTION



It is simple to make an aerial tuner with ordinary receiver components for resonant 10 - 20 m aerials that are fed with coax. The pictured ATU can handle 1.5 kW with the variable capacitors when the SWR is low. The tuning range is comparable to the build in ATU in modern transceivers. I am always using this ATU to ensure I am having a SWR of 1 with a 2 element FB23 or 5 band Cushcraft R5.

DESIGN

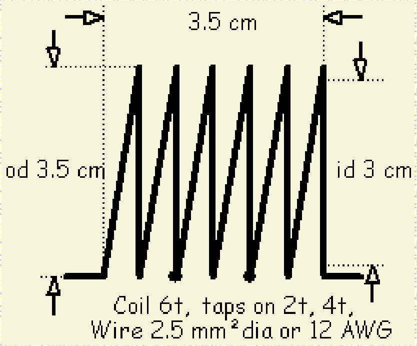


Often two different antenna systems are in use: A longwire for 30 - 80 m and a beam or (phased) vertical for 10 - 20 meters. This means switching the antenna and we might just as well switch the ATU instead.

A separate ATU has the advantage that the ATU can be optimised. The inductor can be designed to have the highest efficiency by making the diameter equal to the length. In a lot of "all-band" ATU's this is not the case. This ATU may well have a higher efficiency than a build-in ATU's of a number of transceivers.

The design is a classic pi filter consisting of an inductor with taps and two variable capacitors. Construction is easy because no insulated shafts or insulated mounting of the capacitor is required.

INDUCTOR

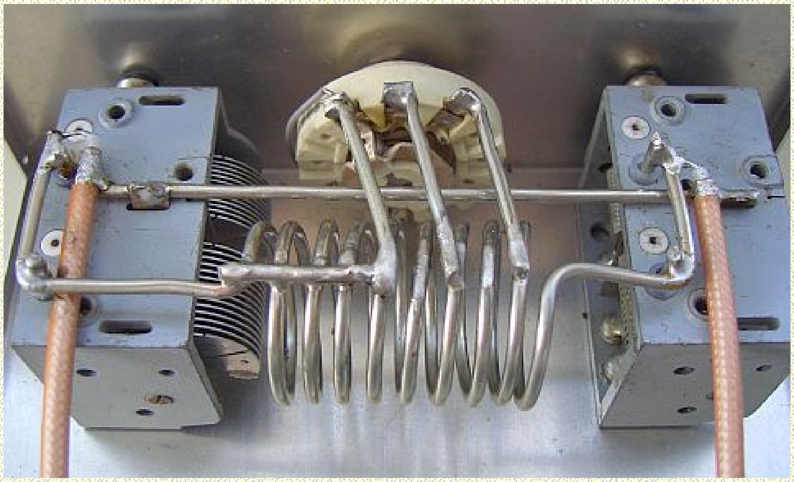


The inductors has been constructed from ordinary unshielded # 10 wire (2.5 mm²) which normally (in NL) is used for grounding purposes in the mains wiring. Six windings with an inside diameter of 1 1/14 " (3cm «fig) are generally sufficient. For me 5 windings were sufficient and the rest of the inductor was shorted.

Ground lead wire

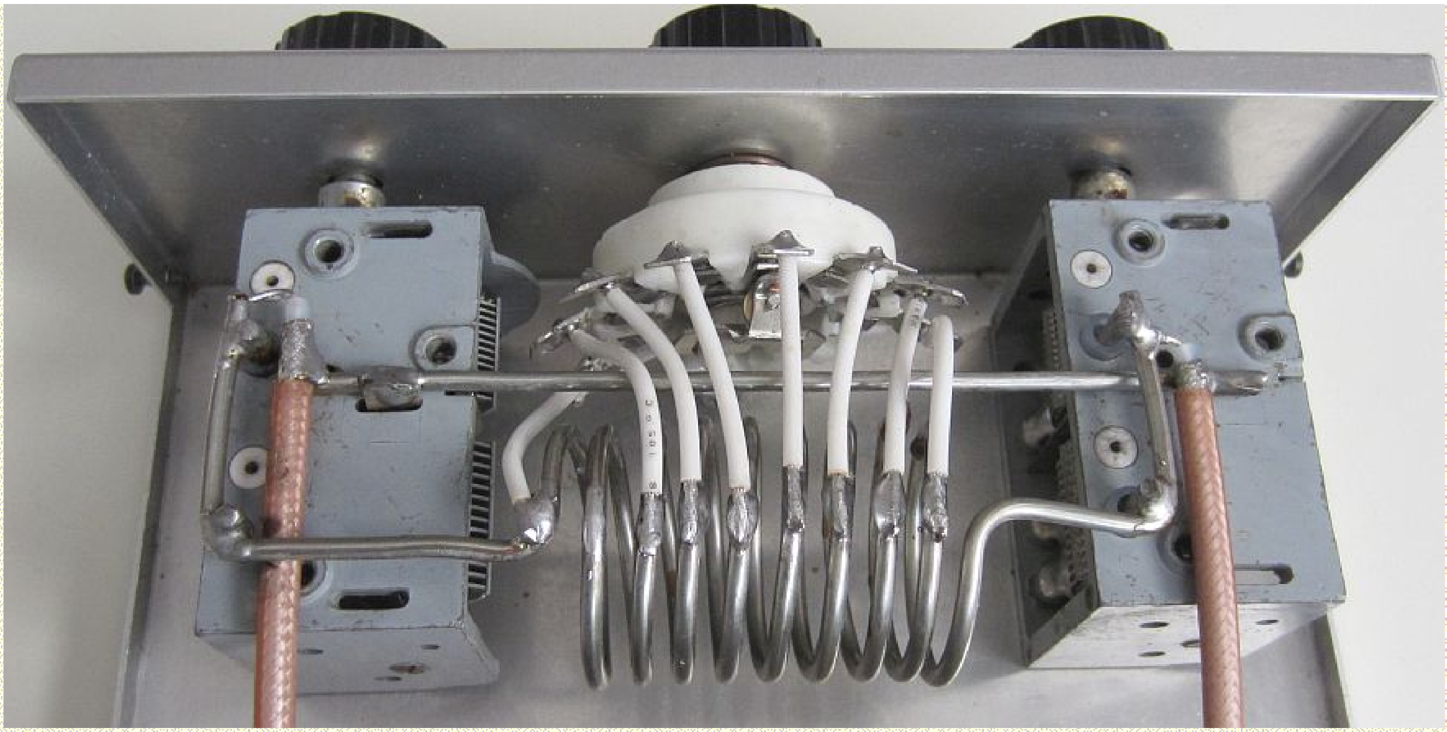
(It was the intention to replace the tapped inductor with a fixed one of 5 or 6 windings but time was spend with constructing something else.) Taps for the switch can be made every two windings. It may be that another tap position works out better in another station but the given set-up is a good start. Thinner wire can also be used initially before making the final inductor of #10 gauge. The length of the inductor is approx. 1 ½" (3.5 cm) if the spacing is equal to the wire size.

SWITCH


A 3-position switch.

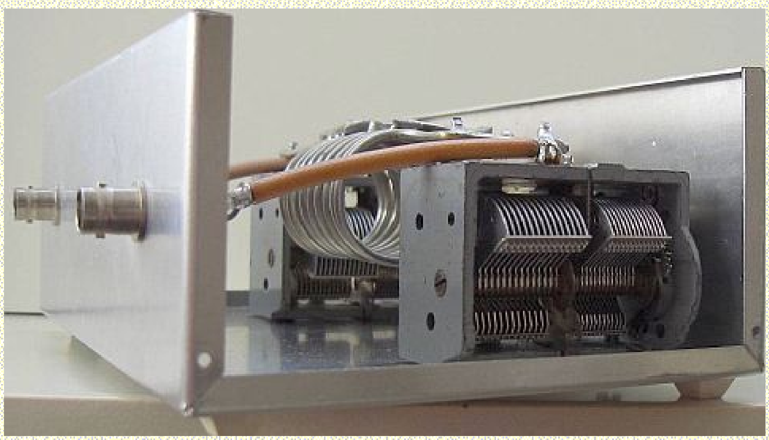

An 8-position switch.

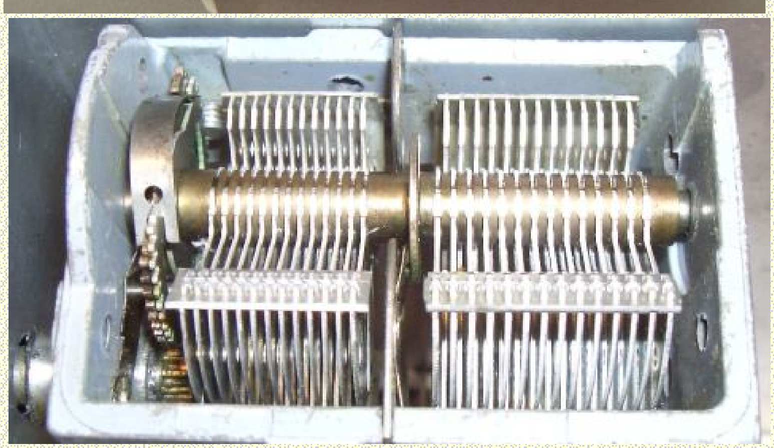
With the 6 or 8-position switch it is possible to make a tap on each winding. In reality this was not required and that's why a three-position switch was used. Large contacts have a minimum RF resistance, which is important at the higher HF frequency.



During a "nothing to do" moment the saved 8 position switch was installed anyway.

VARIABLE CAPACITORS



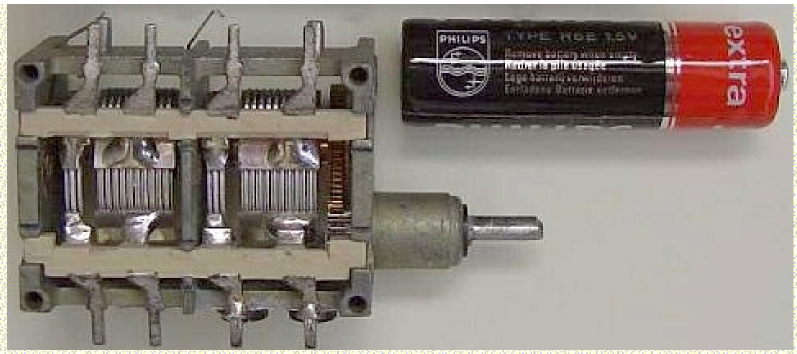


Two section broadband capacitors (fig») with a build-in reduction were used. These can still be found new and on hamfests. Do not pass them up because you think the gap between the

plates is not sufficient. The gap in my capacitors is rather small and the capacitance value is 380 pF per section.

It surprises me that I have not any arcing by rather large transmission power even though the sections have unequal spacing. If you locate capacitors that have a larger gap then that is even better!

If you only use medium power (100 W) then you can use capacitors with very close spacing. Shown (fig») is an AAA battery for size comparison.



Even this type is suited for 100 W.

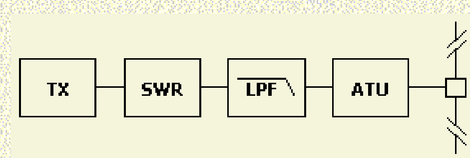
CONSTRUCTION

Connect the parts with the same #10 wire and do not use the chassis for the return path. Use the soldering lugs that are normally used for earth and keep the connections short. Take note how the Teflon coax (fig» RG-142 or similar) is connected to the capacitors. This helps to minimise stray inductance of the wiring, which starts to have an impact when using the ATU on 10 meters.

OPERATION

Some practice operating the ATU is required. Not always is a match immediately obvious and another tap or position of the other capacitor is required. Many aerials have been tested and always has it been possible to create a match.

If you have two settings that have a SWR = 1 match then use the setting that uses the highest capacitance.

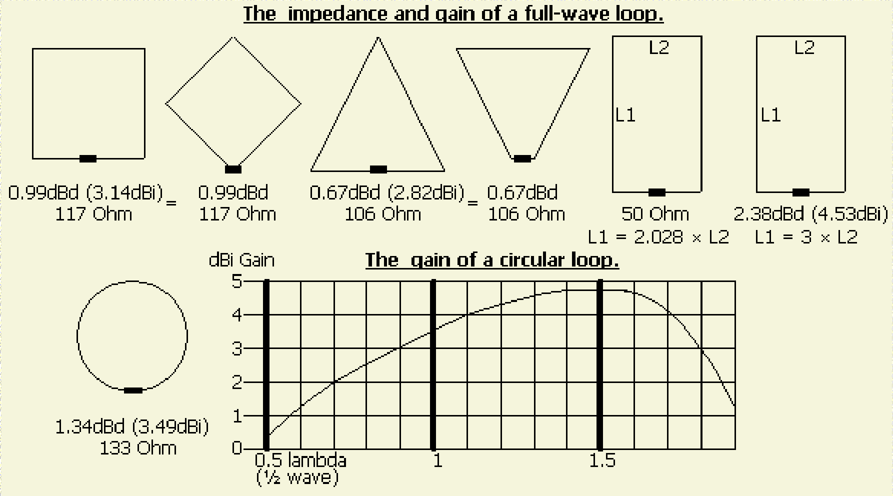


A low-pass filter (LPF fig») is always in use and the ATU ensures that the filter is correctly terminated with 50 Ohms, which is required for the correct functioning of the filter. The filter causes the tuning of the ATU to be sharper and aids in tuning the ATU to a 1 ÷ 1 SWR.

«Back AØFRI

QUAD or LOOP ANTENNA

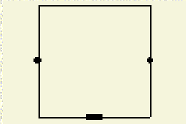
UPDATE **19-01-2011**

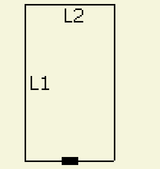


The characteristic impedance of a loop depends on its shape.

QUAD

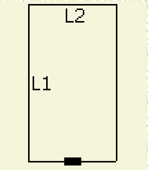
The feedpoint of a full wave length (1 × λ) loop or cubical quad (QQ) has an characteristic impedance of approximately 115 Ω. We see that the shape of the loop determines the impedance and the gain (with respect to a reference dipole). A circular antenna is the best and has in a certain direction 1.34 dB gain with respect to a dipole in the same position. Maximum gain can be obtained with a 1.5 λ circumference.


Two 'stacked' dipoles



2.38dBd (4.53dBi)
L1 = 3 × L2

The low gain of a square is explained by considering the antenna as two stacked dipoles («fig) with a to short distance above each other. One dipole feeds the other one by means its high impedance ends, which you can consider as a ladder line with the wires far apart. If one increase the distance (fig») of the two 'dipoles' with a length to width ratio of 3 : 1, the maximum gain is 2.38 dBd. The impedance of the feed point is unknown to me.



50 Ohm
L1 = 2.028 × L2

To obtain an impedance near 50 Ω («fig) on HF a length-width ratio of about 2.028 : 1 is needed. For best SWR one should experiment with the factor 2.028.

To verify that factor, I have made a couple of 70 cm loops with electricians blue wire. In the center of the 435 MHz band, the SWR = 1.1 at a loop size of 25 × 10.5 cm.

The calculated factor is 25 : 10.5 = 2.38

POLARIZATION

A vertical QQ with a feedpoint on its base has horizontal polarization, the feedpoint on its side change it to vertical. If the antenna is parallel to the surface of the earth, the polarization is horizontal. The antenna becomes more or less omnidirectional and the radiation pattern depends on frequency and antenna height.

IMPEDANCE

The previous information is based on an antenna, which is mounted at great height and under ideal circumstances. The impedance of the antenna close to ground or fitted with directors and reflector drops to a low value of sometimes less then 50 Ω. Usually quads for 20–80 m are relatively close to earth and its feedpoint will be lower (100 Ω) than the theoretical value. The impedance of a half wave (½ λ) loop is 6 - 10 Ω.

ADVANTAGE

A loop antenna has some advantages:

Less noise and interference by local sources.
Lower radiation pattern.
Relative low losses due higher impedance ad its feedpoint.

SIZE

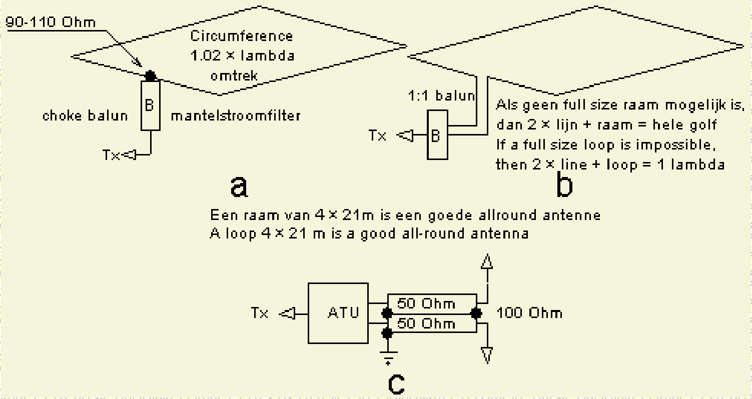
A QQ for one band has a velocity factor of 1.02; its circumference is larger then is usual for antennas.

For example a loop for 3.7 MHz: circumference = 1.02 × (300 ÷ 3.7) = 82.7 m. If the loop is made with insulated (PVC) wire the circumference decreased to about 0.95 × 82.7 = 78.50 m.

If you can not put up a full wave square, a full wave can be simulated with a circumference of 2 × feeder lengths + loop. Differently said: counted from the starting point of the feeder the total length of wire is a full wave.

Although most amateur bands have a harmonious relation, an 80 m loop has not a SWR = 1 on the higher bands.

In the drawing (fig c) you can see that a QQ can be fed with two 50 Ω coax cables in parallel.

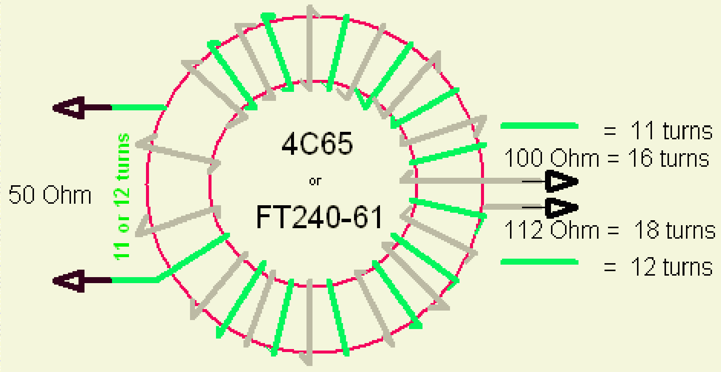


HORIZONTAL LOOP

A horizontal loop (fig a) with a circumference of approximately 84 m is a good "all round" antenna for 10–80 m. It has none pronounced DX or local radiation pattern. It is surprisingly how strong the signals on 20 m are with this antenna. A fellow ham lives 10 km away from my location and uses a 160 m horizontal loop. If I transmit with a vertical or W3DZZ antenna on 20 m his reports are one or two S units stronger. Only if my 2 el. Yagi is pointed in the direction of the DX station, we are just as strong and sometimes my reports are better. It must be said that his loop is in open field and I am living in a residential area with a small back yard. I used a 40 m horizontal delta loop with excellent results at my previous address. The loop was about 5 m above the ground and I used a tuner to match the antenna.

MATCHING

The dimension of a loop is less critical if an open line with antenna tuner is used.

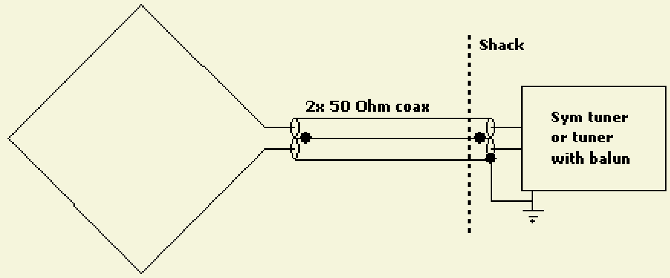


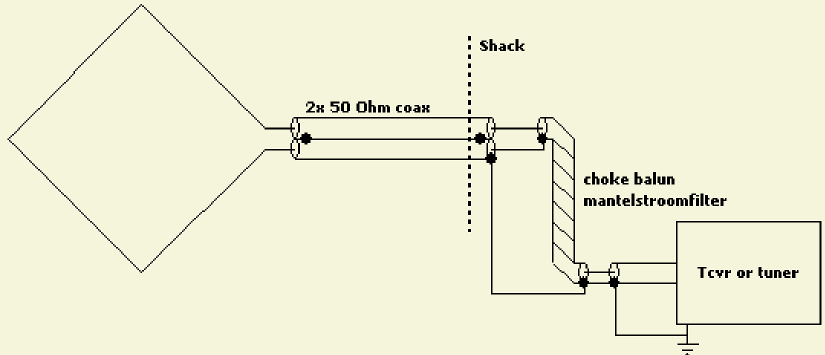
Matching of 110–100 Ω to 50 Ω is possible with a balun. By experimenting with my S-Match antenna tuner I found this way («fig) of winding a balun. A big advantage is the galvanic separation of input and output terminals and coupling of the antenna with the coax shield has been nearly eliminated

Eventually the balance was improved by exchanging respective the wires of the input and/or the wires of the output terminals.

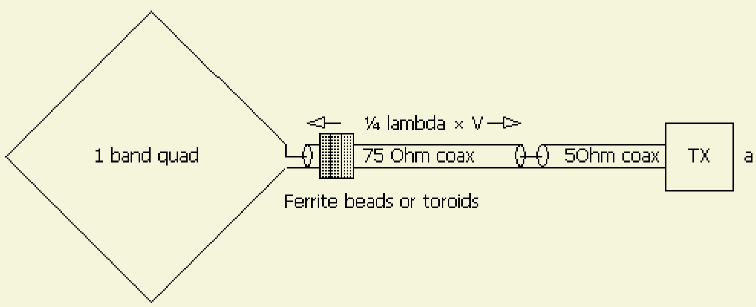
In the range of 10-160 m the balun has sufficient inductance.

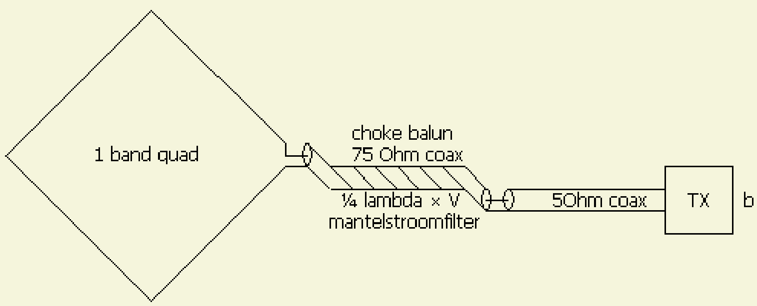
Here (fig») everything has been clarified once more. Also an (internal) asymmetrical tuner in combination with choke balun is generally possible. Wind (for 10–80 m) approximately 3 m coax on a 7–10 cm diameter tube. If the tuner can't find a match, the feeder cables (2 × 50 Ω) could be to long or to short.





SINGLE BAND QUAD



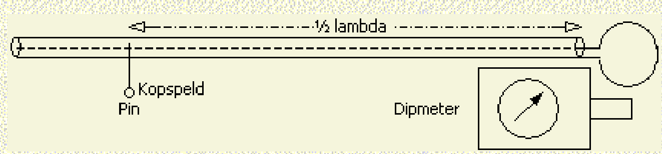


Choke balun of mantelstroomfilter.

A single band quad can be easily loaded with 75 Ω coax cable (fig.a) as line transformer. All that is required is a ¼ λ of line having Z_0 equal to √(112.5 × 50) = 75 Ω. The length of line is ¼ × V × λ and that transforms 50 Ω to 112.5 Ω (Z_{ant} × 50 = 75², Z_{ant} = 5625 ÷ 50 = 112.5 Ω). "V" is the velocity factor.

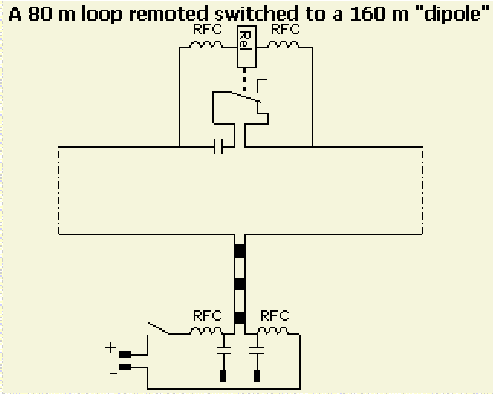
To prevent currents appearing on the outer conductor, wind the cable (photo) a couple of turns through toroids or use a choke balun (fig.b) close to its feedpoint with turns of 3–6 m length of coax on a 8–12 cm diameter pipe.

I use a (grid)dipmeter to determine a piece of ¼ λ cable. I cut a length of slightly more than ½ × V × λ and solder a small loop to one end. Then I short-circuit with a pin through the screen the other end and measure the resonance. After a couple of "punctures" one finds the correct half wavelength and half of it is the correct size.



Matching with a ¼ wave or ½ wave coaxial cable is pretty well known, but it also can be done with an existing 1961 system: [two one-twelfth-wavelength transmission lines]

80 OR 160 m ANTENNA


A 80 m loop remoted switched to a 160 m "dipole"
RFC
Rel
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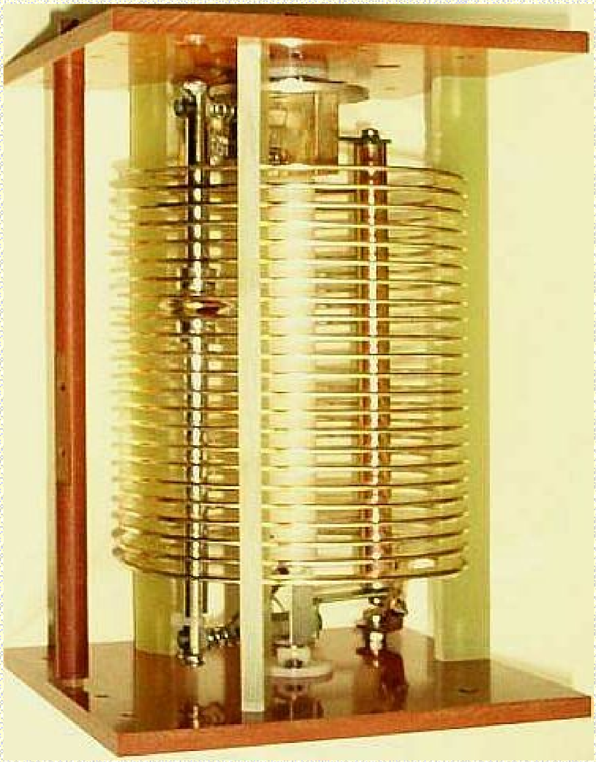
« Back

PA0FRI

ROLLERS

(Roller inductor)

TO BUY

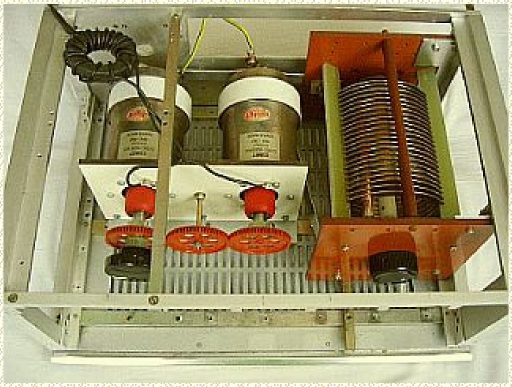


Reel reel purchased from Colomor.

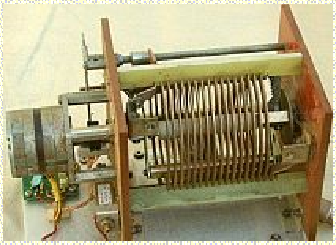
Various beautiful reels were offered by ~~www.colomor.demon.co.uk~~ , but their free provider stopped and the seller is only active on eBay.

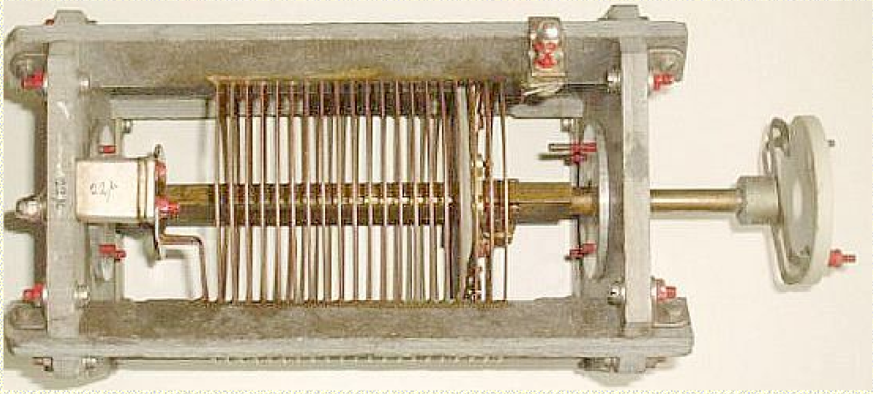
In the Netherlands, many types of reels can be found at: http://www.elektrodump.nl/ , click on Spools.

The picture is from a 26 μH (here measured) Redifon (Racal) reel that I bought from the English company. The coil turns very light because the guide rod with roller is balanced by another rod that you see on the right of the picture. If the tuning knob gets a push, the shaft turns a few revolutions.



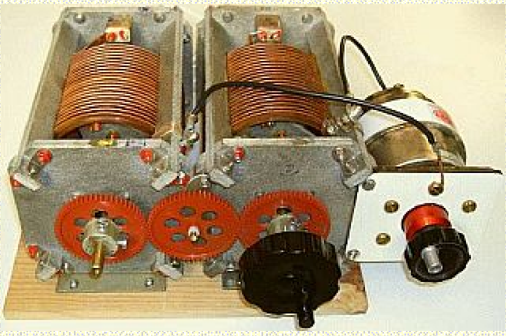
Please note, due to the English and transport costs to NL there is a reasonable price attached to it, but such a quality coil coil will last an (amateur) life.





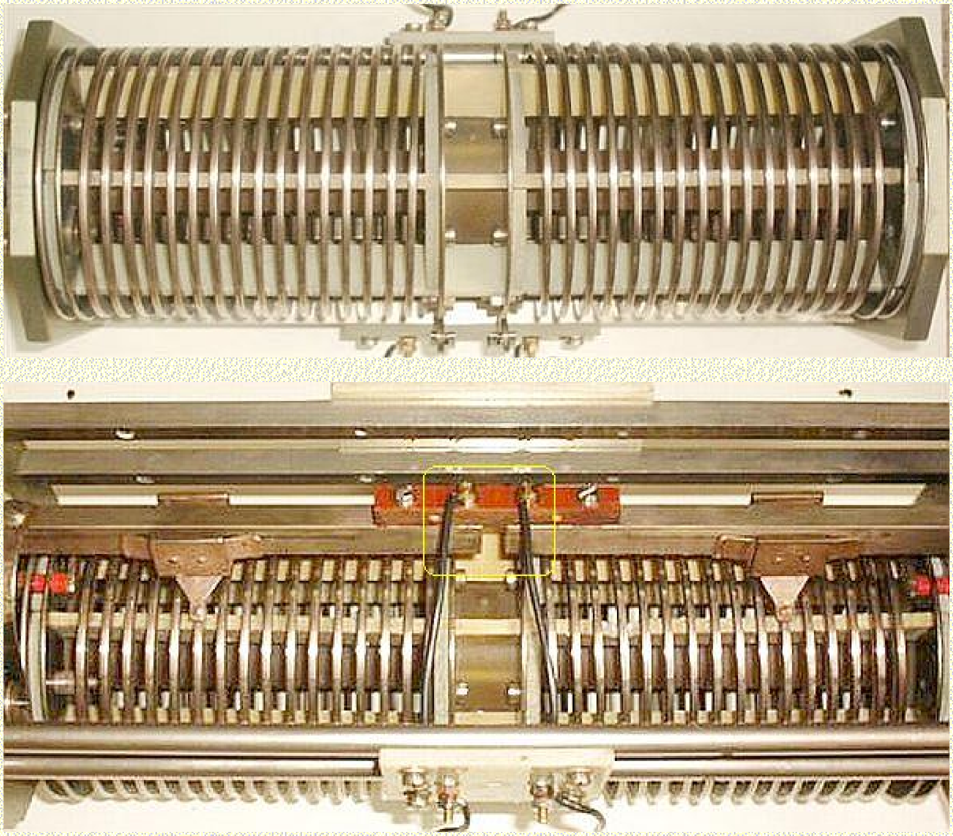
Repaired 22 μH reel of flea market Rosmalen

It is regularly claimed that there are no reels for sale on flea markets. It is still a matter of looking around and bidding well. During the flea market of Rosmalen on March 20, 2004, I bought the above Russian 22 μH reel for about € 1530 around 1530. Given the late hour of the purchase, many people have looked at it and turned it on. They refrained from the sale because it was stiff and a few windings were bent.



The roller coil did not have to be disassembled. The windings were returned to their original shape with a pair of jaws, and everything went smoothly after cleaning and oil-cleaning. On the photo the "damage" is no longer visible. The role coil now looks like new and works perfectly!

Meanwhile, an identical copy was bought on eBay via eBay.de and both reels were used for new tests (fig ») with various ATU systems.



Modified reel of flea market Bladel

This double coil coil also had many in their hands. It was built up with two unbalanced coils that were connected to each other on one side (bottom) with a shower bar (why?). The guide rod was cut through here later and connected to each other for insulation and reinforcement with a strip of insulating material. It has now become a well-functioning double coil coil of 2 × 11 μH that can handle a lot of power.

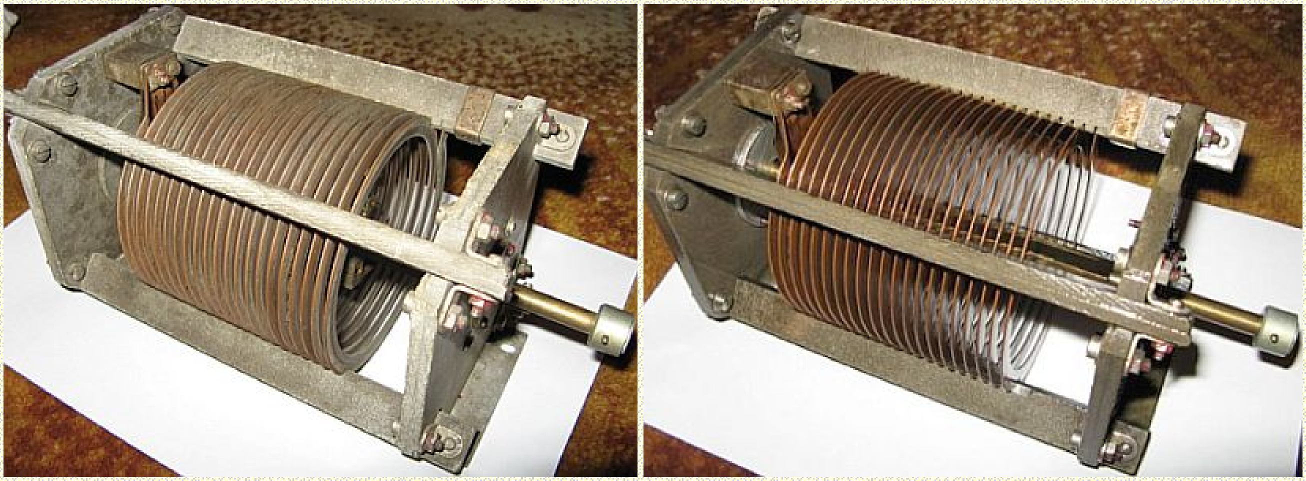
LUBRICATION

A (Russian) reel can for example be cleaned with:

(1) Valvoline Engine Cleaner (spray can)

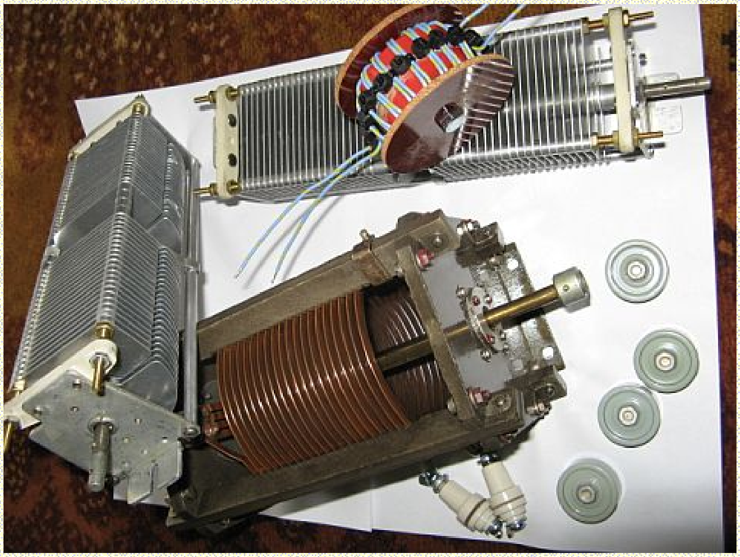
(2) A brush with turpentine or complete rinsing, or. soaking in benzine or turpentine.

(Sometimes I do a component in the dishwasher, but with this type of reels I have not tested it.) Then rinse under the hot or hot tap and let it dry at or on a radiator or outside in the sun. Then inject or lubricate with silicone oil / spay, especially the sliding contacts at the round disc behind and the contacts and conductors running over the coil. The bearings get the same lubrication, but one can also use another suitable means. If the coil still does not run smoothly, it has already been disassembled and put together incorrectly. The conductors over the coil and the contacts over the coil must lie well in a certain plane, otherwise friction will occur. This is difficult to describe, but by looking at it it will become clear whether or not it is right.

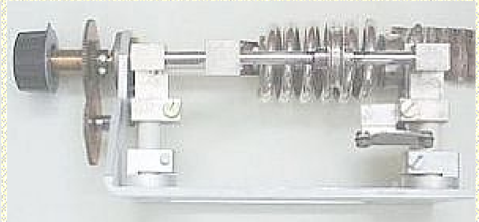
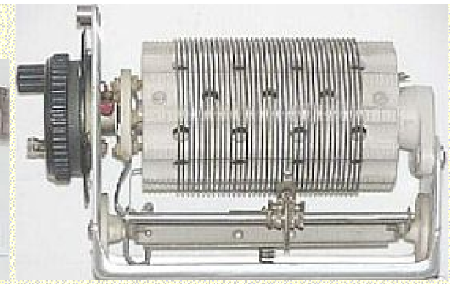


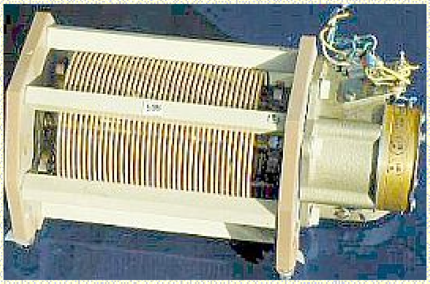
PH4U followed the advice and this is the result before and after the treatment. Quote: "The coil turns like a tierelier again".

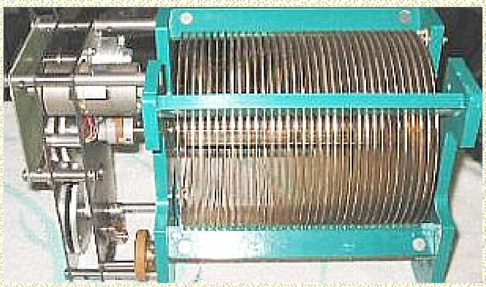
By me everything was used as a lubricant for roller coils and what I like best so far is silicone spray that is available almost everywhere. Actually, it was a desperate act because all previous preparations did not work satisfactorily. I expected the silicone oil to work as an isolator for HF energy, but that has not been proven. Here, axles, windings, rollers and sliding contacts are successfully lubricated.

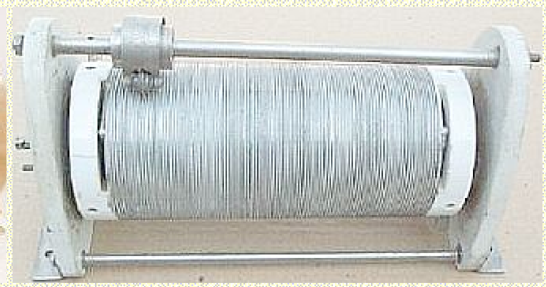


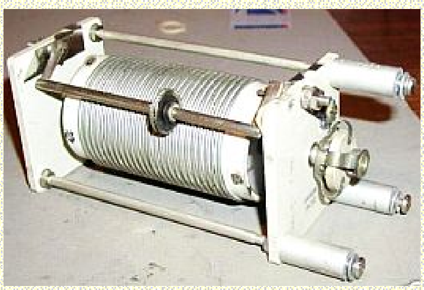
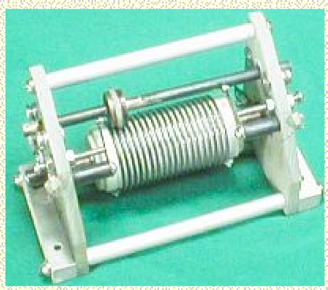
This way, the cleaned roller coil is even better.

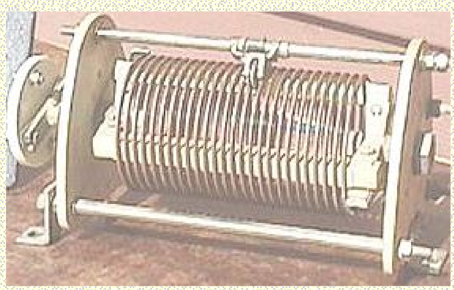








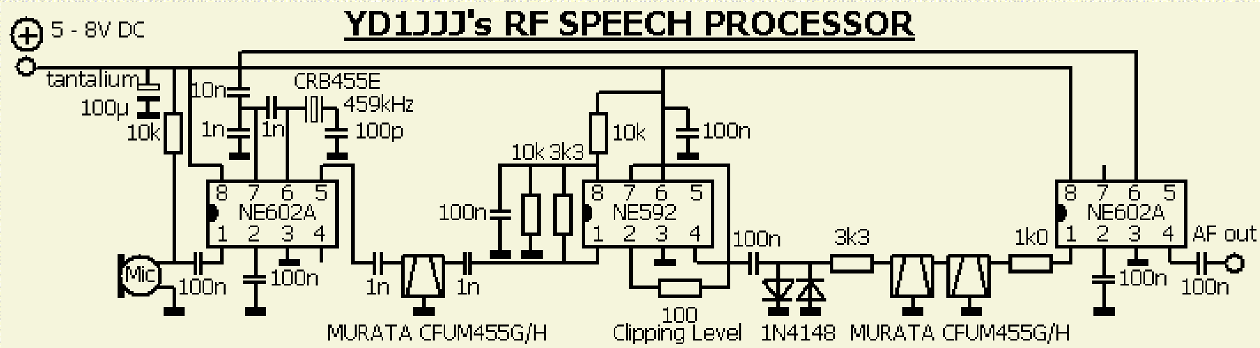




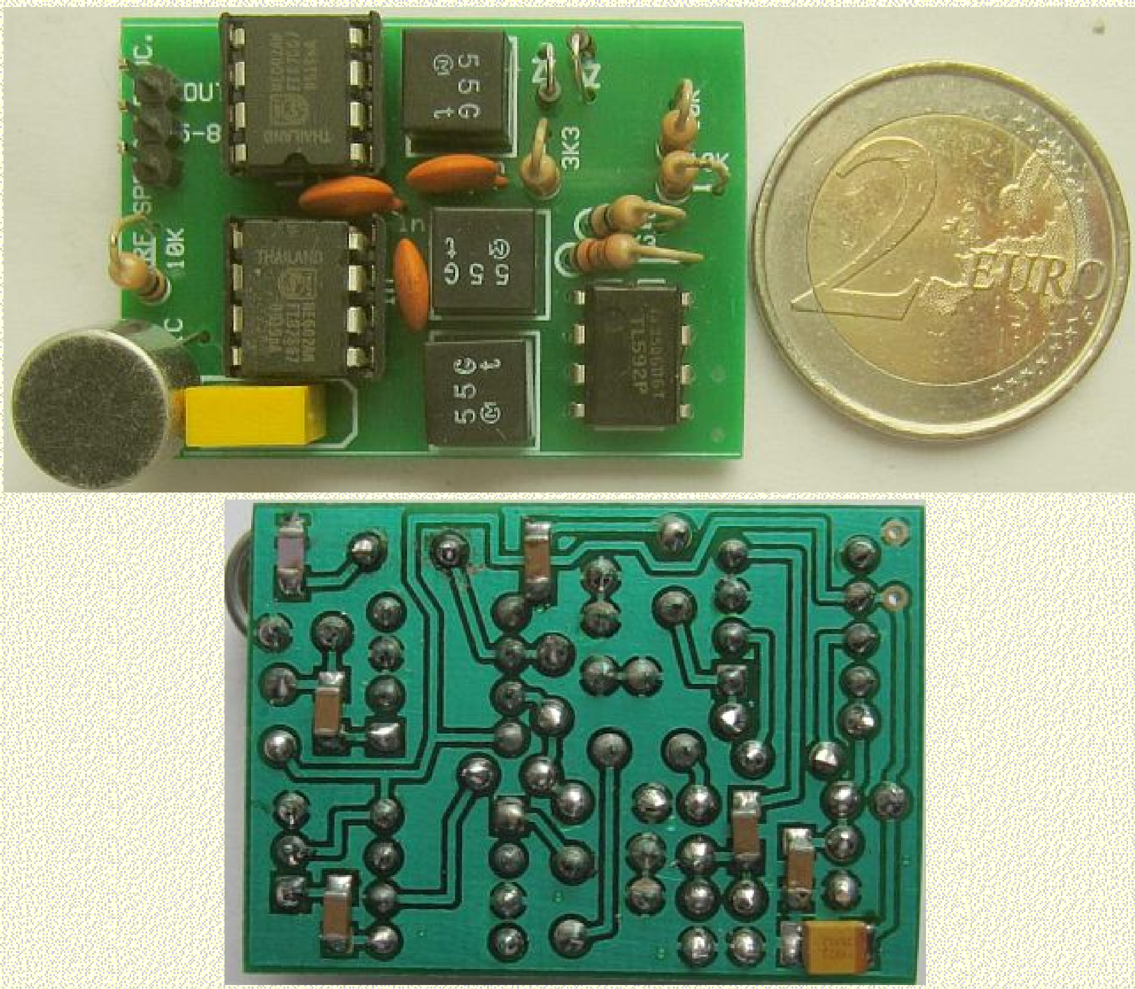
YD1JJJ RF SPEECH PROCESSOR

29-aug-2016



YD1JJJ's original design.

INTRODUCTION



Miniature 5 × 5 cm PCB, good quality and components properly installed.

On eBay I discovered an ad of an outboard RF speech processor designed by YD1JJJ. It was originally a kit for DIY, but this PCB was assembled and tested.

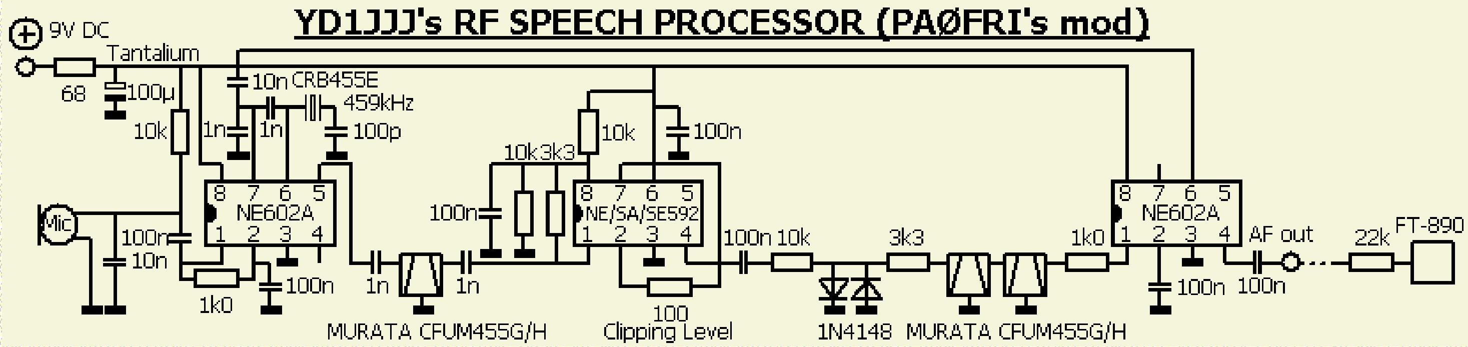
The Rf clipper is intended for mounting into a (fig») MH-31 microphone for FT-817, FT-857 and FT/ND-89 transceivers, but in my opinion it can also be used otherwise.

Because of the simple circuit, low price and my experience with RF or DSB clippers, I was curious how it would work in practice. Therefore it was ordered and the total cost including shipping from Indonesia were about 24.72 EURO. That can't be a bad buy!

It turned out to be good quality PCB with properly installed components, that can be seen on the pictures above. The accompanying documentation was only in Malay.

IN PRACTICE

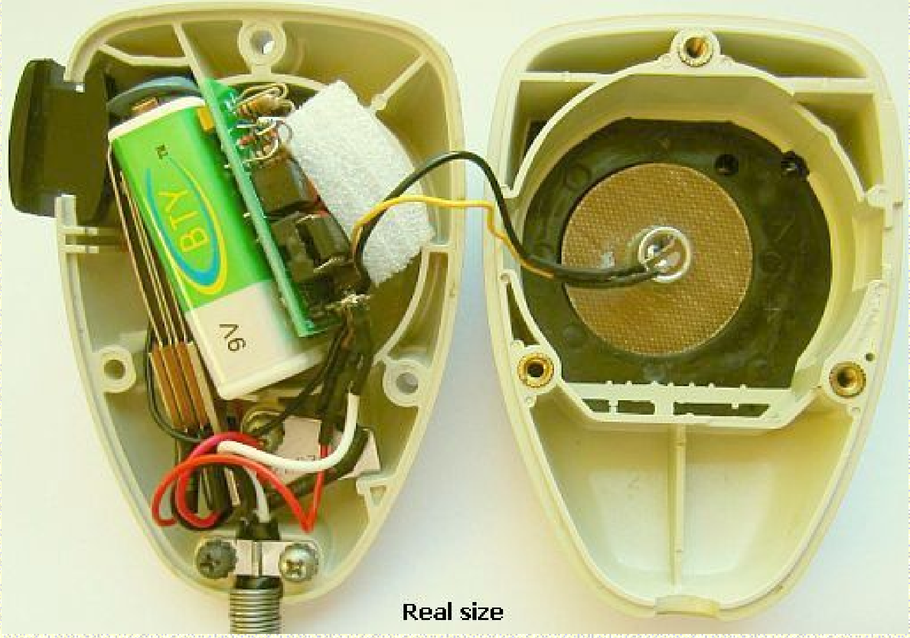
In practice, the gain was far too much resulting in sharp modulation peaks and pretty annoying background noise.



NE592 = SA592 = SE592 ~ µA733

Apparently too much signal from the microphone because the input of a NE602 can be overloaded fairly quickly. The modification was held simply to avoid damage of the tiny PCB.
The microphone was extra loaded with a 1k0 resistor mounted across pins 1 and 2 of the first NE602A.
At the delivered speech processor pins 2 of of both NE602A's were not decoupled with 100 nF. I decoupled the first IC because a floating input can pick up all kinds of unwanted signals and is sensitive for RF feedback!
Which I have been afraid of was also happened: the electret microphone was suffering from RF feedback. Instead of the much applied decoupling with a 1 nF capacitor, I did it with 10 nF. Audiophiles will have their doubts with this value, but my experience is that with ham SSB it works and RF is decoupled more effective. In this circuit the microphone is loaded with 600 Ohm (1k0//1k5) and 10 nF relative to 1 nF makes little difference in terms of audio.
The clipping diodes were equipped with an extra 10 kOhm series resistance and as bonus one gets a logarithmic clipping with less distortion.
Because the microphone gain of my FT-890 is very large, a resistor was mounted between speech clipper and microphone input.
The 9 V supply voltage is reduced by an 68 Ohm resistance in series with the positive terminal of the battery.
Due to all changes all reports are: loud speech but sounds good, however further developments are not impossible.

INSTALLING MICROPHONE CASING



Because the audio speech processor of my YAESU FT-890 is not really great, the goal was to test YD1JJJ's design with this set and to merge "in a moment" the PCB with a microphone in his enclosure.

A relatively small FT-890 is so densely populated with components, that there is almost no room for an extra PCB or components.

The "in a moment" did not work because all 8 pins of the microphone input were occupied, so that without heavy labor an additional DC voltage from the set was not easy to obtain.

Supply and clipper had to fit together in the microphone casing. Luckily after some messing it was possible to join both in («fig) a MOTOROLA type.

If the dual microphone switch is turned on at first the 9 Volt battery is connected and in sequence PTT is activated.

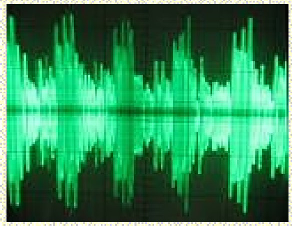
A floating microphone in an enclosure is usually asking for misery, because the sound is adversely affected by the echo of the space. Therefore, the electret was mounted in a front panel, so that the voice only ends up into the microphone.

ADJUSTMENT

The problem with speech processors is that many hams want to have the extreme, so that it sounds unpleasant for the receiver. The goal is in fact strived beyond. Less clipping is the cure. Adjusting using a scoop is fine, but without can also be done.
If one speaks normally into the microphone with a 100 W transmitter, the needle of a mechanical PWR-meter (not PEP mode) shows an average 10 W.
In the CW mode and with quick points the meter shows an average 30 W. With heavy clipping one can push the meter also for an avarage 30 W, but that is to much.
Better is to decrease the clipping for an average of 20 W. Often one don't notice that an processor is active, while the average ouput is increased significantly. I estimated about 3 dB.
Adjust Mike Gain of the set as follows: whistle into the microphone and increase the gain for maximum (100 W) output. Then reduce for an output of about 90 à 95 W. How load you speaks into the microphone, the output stage of the set can not be overmodulated and ALC remains moderate.

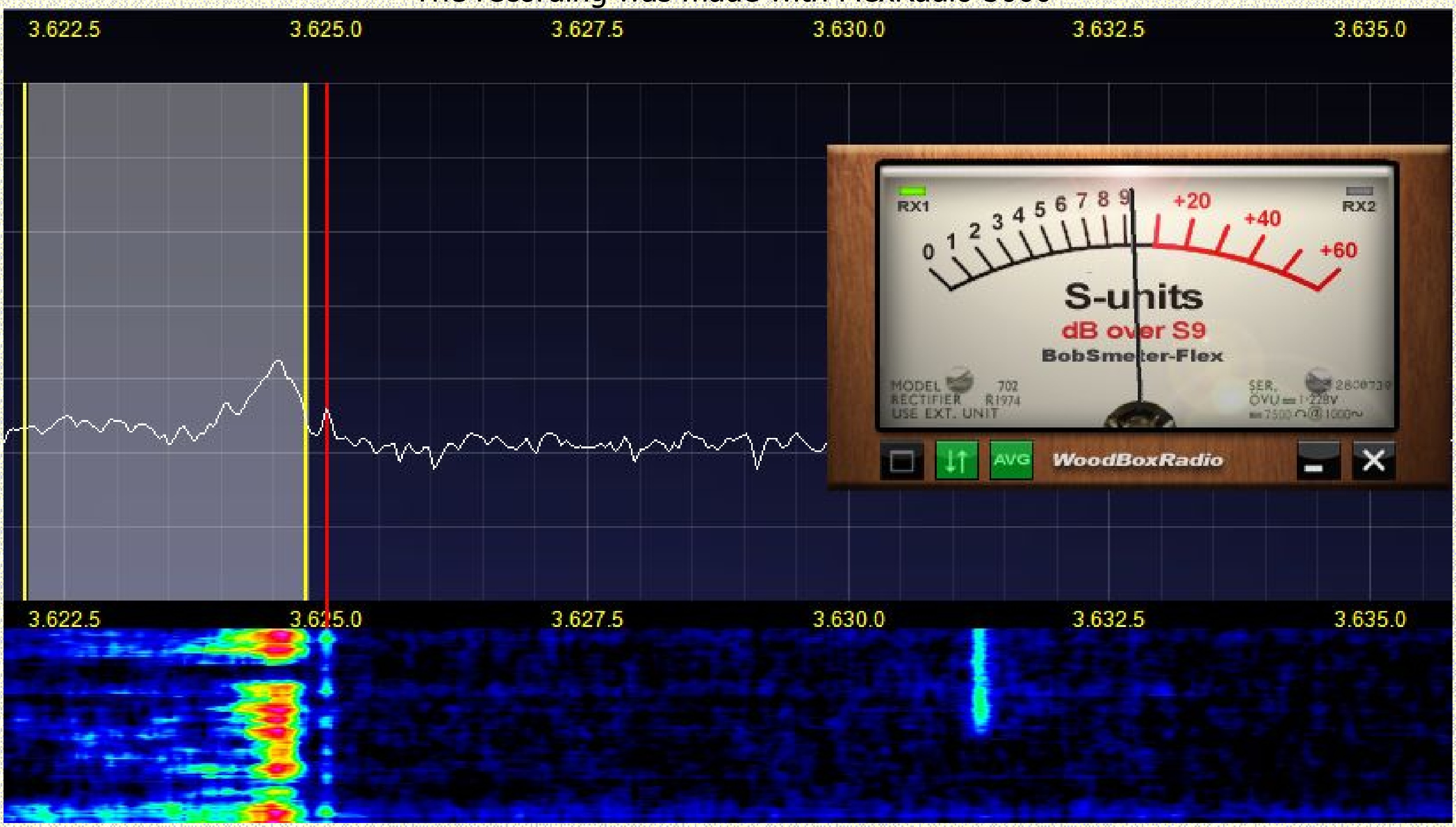
CONCLUSION

YD1JJJ has designed a striking and simple processor. The small size is due to his search for the smallest possible filter: MURATA CFUM455G!

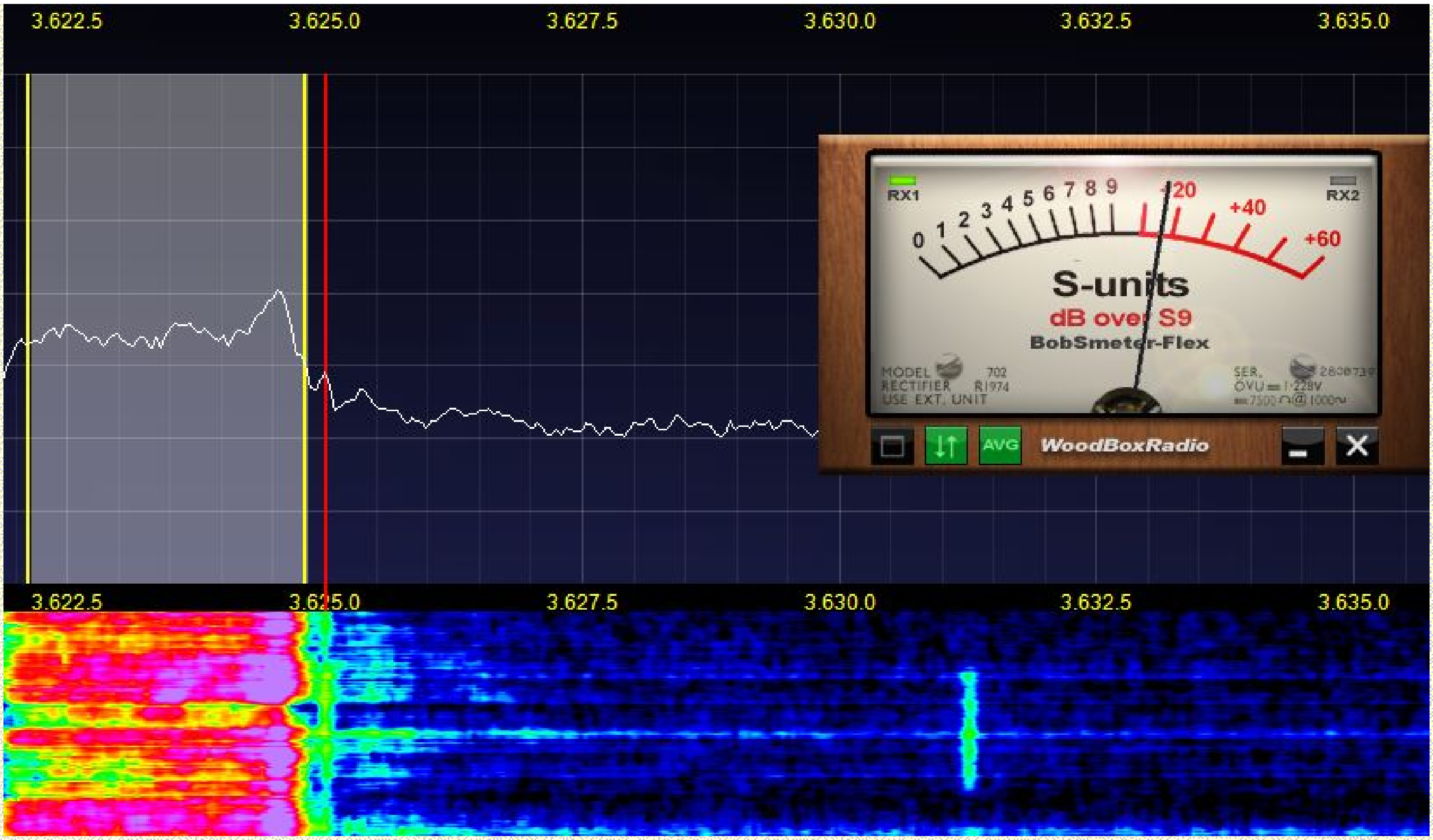


The speech clipper, you may have to modify a little, works very effectively. An example: the fan of my FT-890 starts much earlier: an indication that average ouput (fig») increased.

The recording was made with FlexRadio 5000



Without processor with original MH-1B8 dynamic microphone and average 10 W SSB output.



With processor and electret microphone. Due to clipping an average of 30 W SSB ouput.
The S-meter shows increase in average power. The waterfall also indicates that the signal is better "filled".

Both recordings are done almost immediately after each other by fast swap of the microphones, so that a comparison of the outcome is almost 100% sure. Because the S-meter of a FlexRadio 5000 is pretty accurate, one can see that by applying the processor the (averagel) ouput has at least quadrupled.

RUSSIAN STRAIGHT MORSE KEY

RUSSIAN KEY

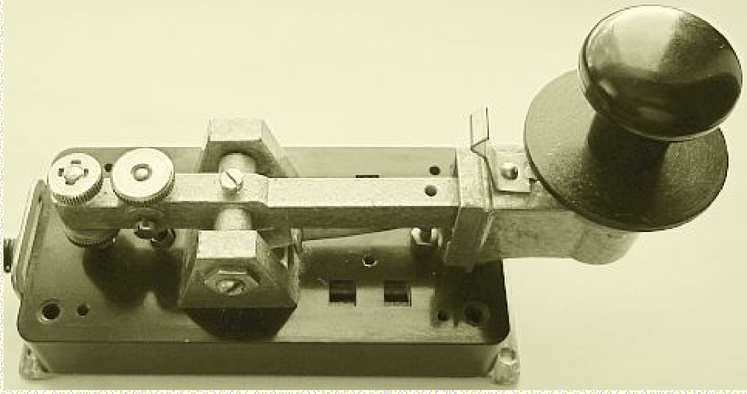
The above straight key was originally purchased out of curiosity at an eBay auction but quickly went on the air. This type is not common when you surfing the Internet. In the search I have found more than 450 different straight Morse keys, for me, an amazing number. I'm not sure about the origin of this key. W1TP writes on his website that it was used with the high-powered R-102M radio sets.

A second source mentions that the key was intended for use with radios that are mounted on tanks. The contacts are trapped inside the cap to prevents sparks from spreading and avoid fire or explosion. According to another informant all Warsaw Pacts countries used the key for type R-102M, R-118 and R-140 radio stations.

I has noticed that Russian military keys for tactical use are black coloured and keys for static transmitters are grey hammer-finish painted. There are still doubts, because the device was offered on eBay as Polish or Hungarian key. I did not found a 100% reliable information.

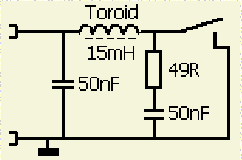
Why this product? Everybody is different but I wanted more attention for this type. I really like this traditional straight key and it even replaced my Junker as (fig ») first key!

PRACTICAL USE



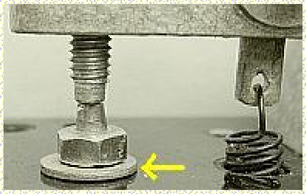
The device handles extremely well, smooth as silk and minimal fatigue! Slowly or quickly keying is possible, it feels good, it keeps dust and is stable on a slightly rough surface. It is best to mount the unit on a desk or a thick metal plate. Furthermore, it is very suited for training or someone who want to learn CW.

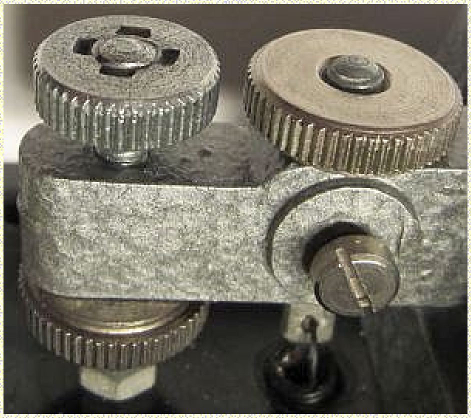
FILTER



The (fig») lower black Bakelite base is assembled with a filter, possibly an anti-click system. I measured the value of the components. Probably the resistor is 50 ohms, but my Fluke77 shows 49 Ohm.

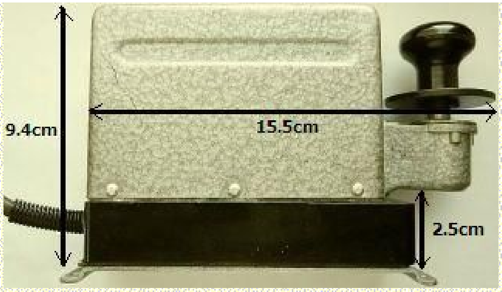
LOCK NUT





For some operators the minimum contact cap is to wide with («fig) the knurled lock nut at its original place. Screwing the contact pin on the black base upwards can reduce this. That takes a lot of work and it can easily through moving (fig») the lock nut below the metal lever.

DIMENSIONS

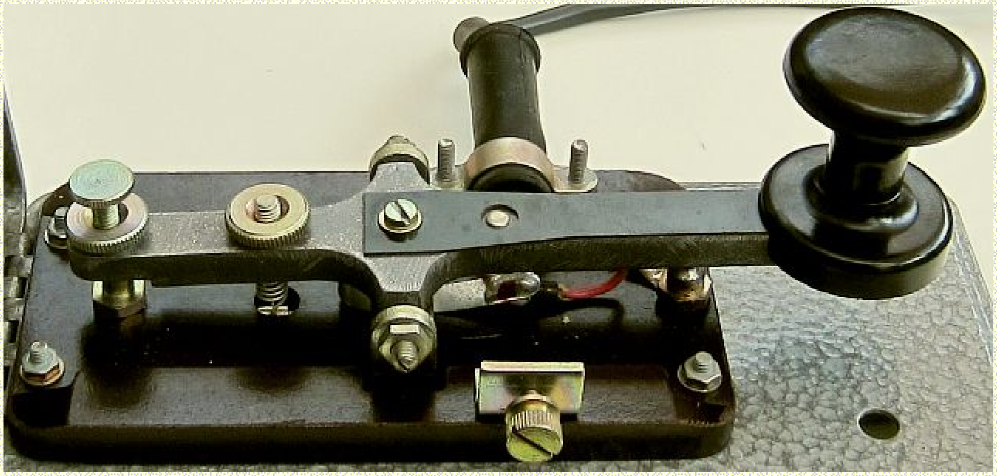


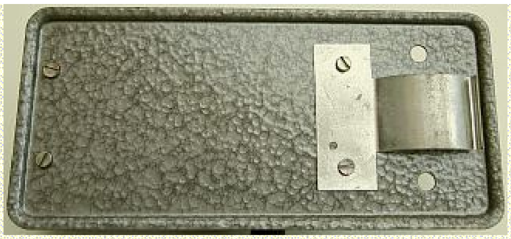
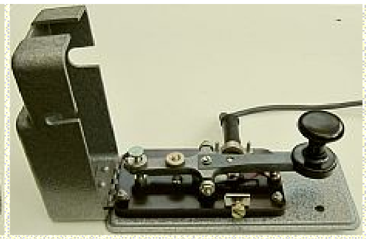
MORE KEYS

I not really collect, but if there is an interesting key offered for a price that I want to spend, it will be purchased.

Part of the "collection" was a gift.

1. **Vibroplex Lightning No 190992 (Type No 6, 1927-1979)**
2. **Hi-Mound BK-100**
3. **MFJ-564 DeLuxe**
4. **KENT TP1-B Twin Paddle**
5. **ZA-4364 No.9, ZA-28656 No-19**
6. **ZA TASTER TS-4 (former JNA)**
7. **J-37-Gy Army Signal Corps**
8. **SATO (training key?)**
9. **Mc Murdo (lifeboat and UK, AU post-WWII fieldradio sets)**
10. **J-37**
11. **Junker S Mobile**
12. **Warsaw pact key for R-102M, R-118 and R-140 radio sets**
13. **Mechlabor key, see the photo's below**




MECHLABOR key made in Budapest (1945 - 1985) for Warsaw pact.

« Back

A RUBIDIUM DISCIPLINED 10 MHz OCXO

(SM0FLY, July 2011)

PRE-SCRIPTUM

This mini project was 'forced upon me' as I purchased a PC based spectrum analyser 'Signalhound'. See the website www.signalhound.com for detailed info. As this spectrum analyser is a USB powered device, a stable built-in low noise reference oscillator in the analyzer is not an option with today's limited power handling on USB PC ports. Hence, an external 10 MHz oscillator reference should provide the necessary absolute frequency accuracy as well as the low sideband noise requirements.

RUBIDIUM AND OCXO FREQUENCY STANDARDS

Numerous devices are available on eBay that satisfy our demand for an accurate 10 MHz reference regarding frequency accuracy.

For a handful USD, the following Rubidium 10 MHz standards were purchased via eBay and flea-markets:

- Efratom FE5680A
- LPRO-101
- AT&T (new, unused spare part)

A well known limitation of Rubidium standards is the relatively high nearby noise and/or spurious at the carrier, expressed in dBc/Hz. This was clearly noticed by measuring the above devices.

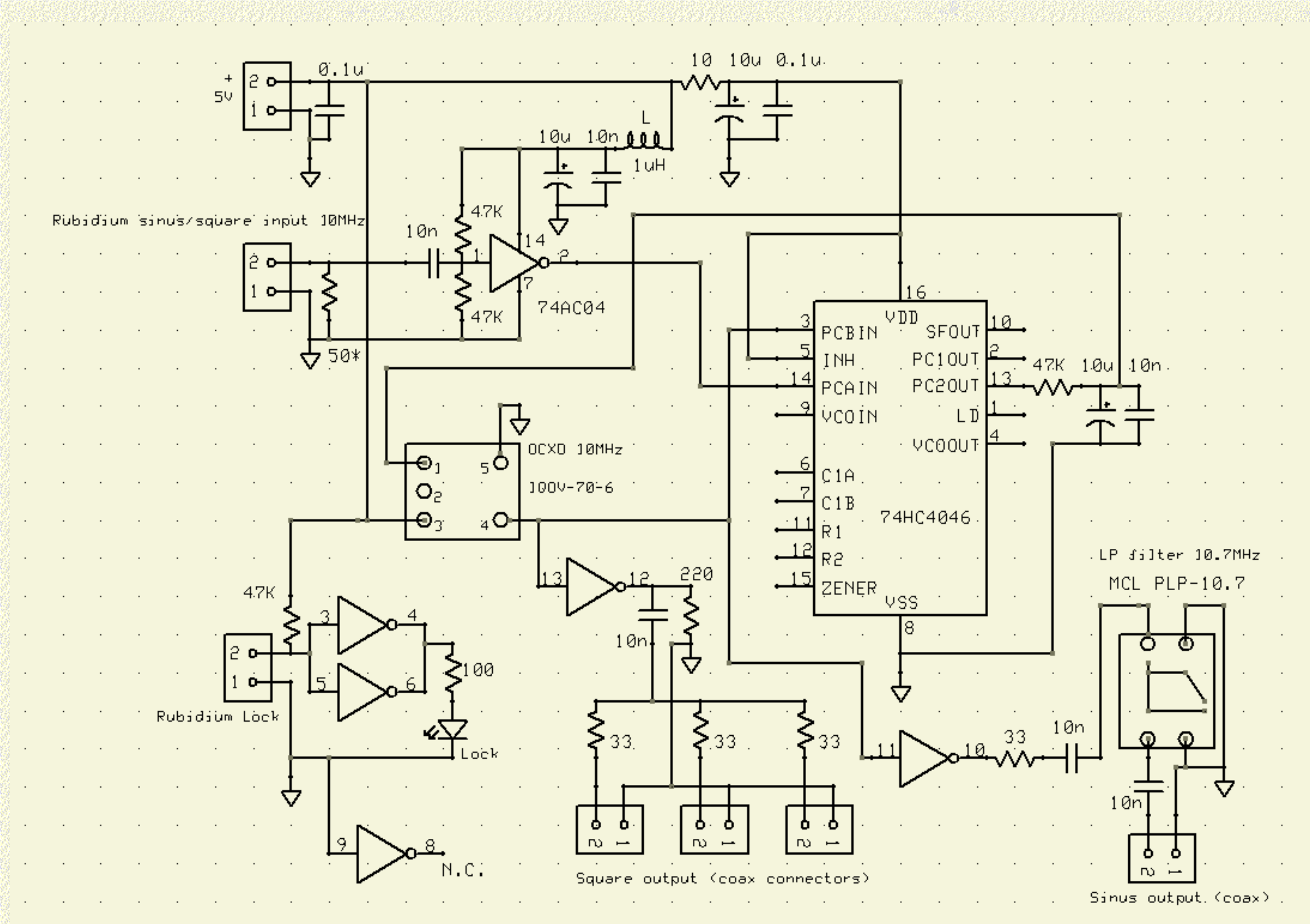
A simple ovenized crystal oscillator OCXO has a remarkable lower noise sideband and is therefore preferably implemented in SDR's or synthesizers in general. The used PTOC32227 from FOQ Piezo Technik, today available as IQOV-70-6, has < -145 dBc/Hz at 1KHz distance from the carrier.

The task is therefore to combine the OCXO low noise specifications with the Rubidium absolute frequency accuracy.

OCXO WITH RUBIDIUM FREQUENCY ACCURACY

The above problem is easily solved by locking the OCXO (PTOC32227 at eBay) to a Rubidium standard. Another alternative is to discipline the OCXO to the GPS system, however this needs an antenna, external wiring, and makes it overall less portable.

The circuit diagram below shows the solution. The OCXO, with a voltage controlled input that allows a few ppm frequency change, is locked via a PLL formed by the phase detector part of a 74HC4046 to the Rubidium standard. Time constant of the PLL to the OCXO is kept at approximately 0.5 seconds at pin 13 of the 74HC4046.

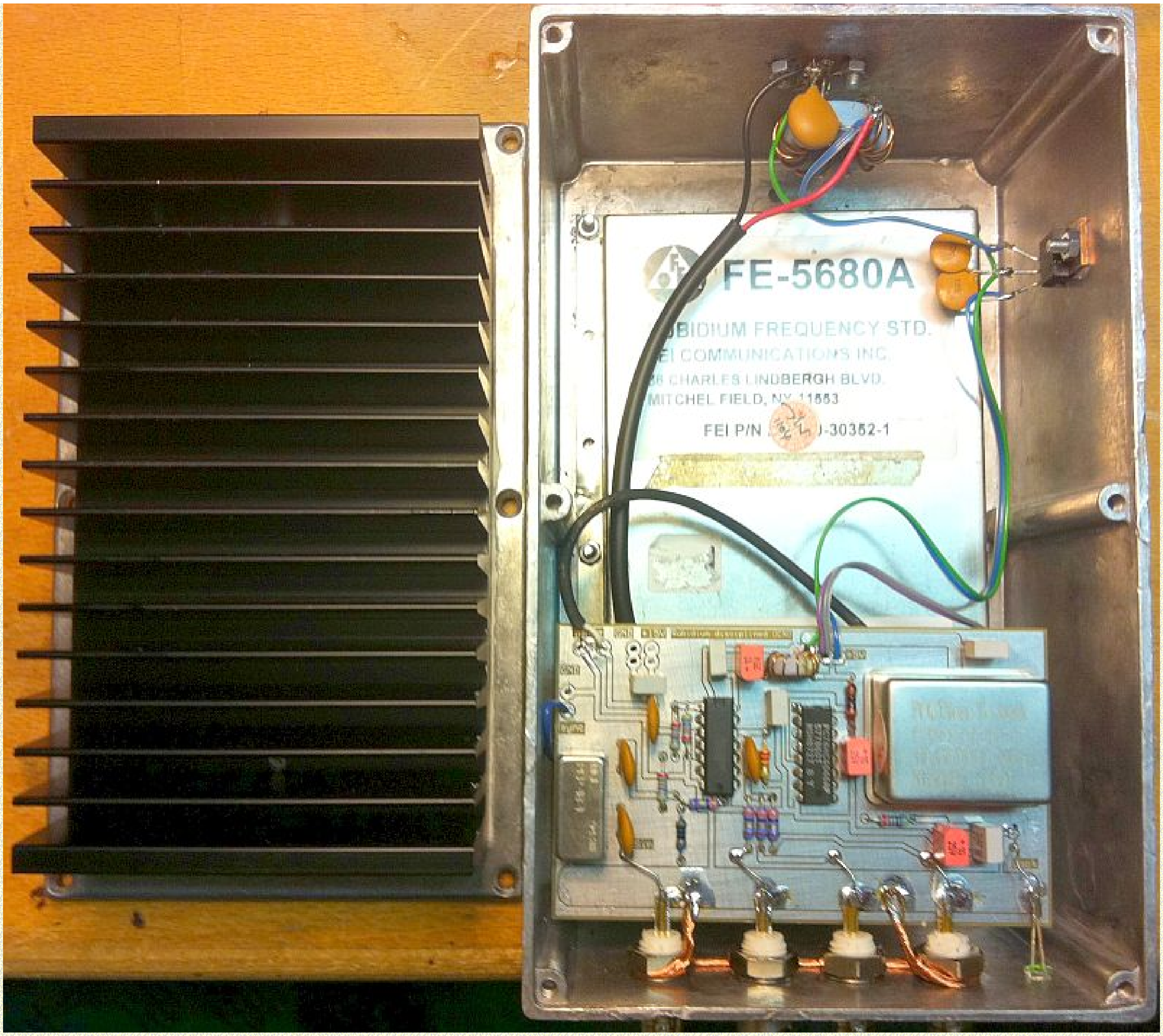


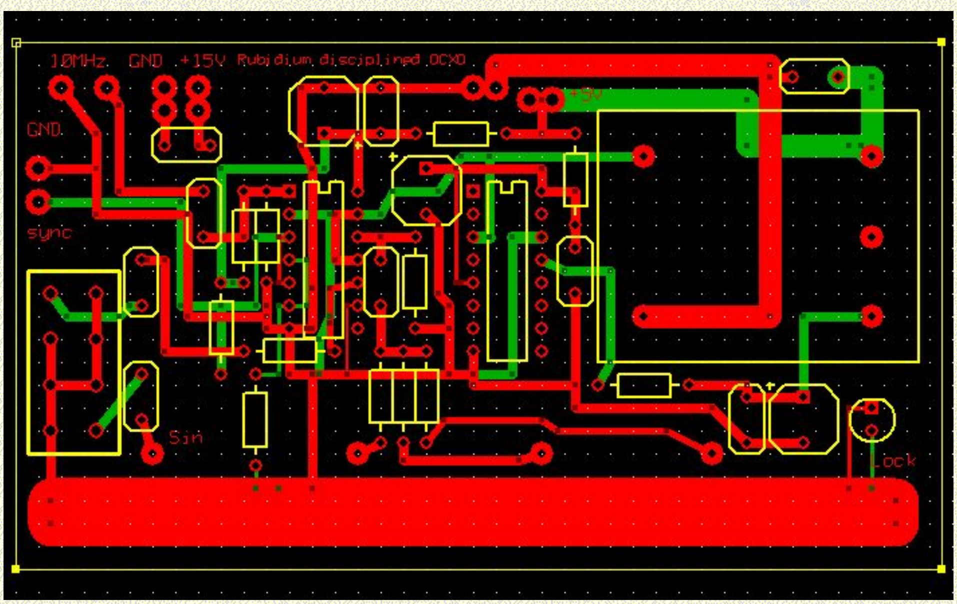
A 74AC04 is used for signal 'shaping/driving' and input handling for the PLL 74HC4046. Three (3) outputs with square wave are available for optional use for frequency counters, SDR's or auxiliary devices that need low noise accurate frequency references.

A Mini-Circuits LP filter PLP-10.7 is embedded in case a pure 10MHz sinus is required for other purposes e.g. long transmission lines.

PRACTICAL BUILD-UP

Image below shows the implementation of the above circuit diagram. The heat sink is removed for this picture only. The OCXO is disciplined by the Efratom FE 5680A. Note that most Rubidium standards need approx 2-3 Amps at 15-24 Volts at start-up and the OCXO between 0.3 and 0.6 Amp at 5 Volt. The whole unit is therefore powered by an external low cost laptop-intended switched PSU. The 5 Volt for the logics and OCXO is accomplished by an internal 7805 circuit built into the box as shown below. A solid heat sink is a must to keep the maximum temperature within the Rubidium/OCXO specified range.





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2. http://en.wikipedia.org/wiki/Rubidium_standard

3. http://en.wikipedia.org/wiki/Allan_variance
4. http://www.rell.com/resources/RellDocuments/SYS_27/IQOV-70-6%20Iss%201.pdf
5. http://www.minicircuits.com/pdfs/PLP-10.7.pdf
6. http://www.datasheetcatalog.org/datasheet/philips/74HC4046A.pdf

«Back AØFRI

INCREASING VOLTAGE SERVER SWITCHED POWER SUPPLY

TYPE DPS-800GB A = ATSN-7001044-Y000 = HSTNS-PD05 (HP, Delta en Fujitsu)

UPDATED **13-mar-2017**

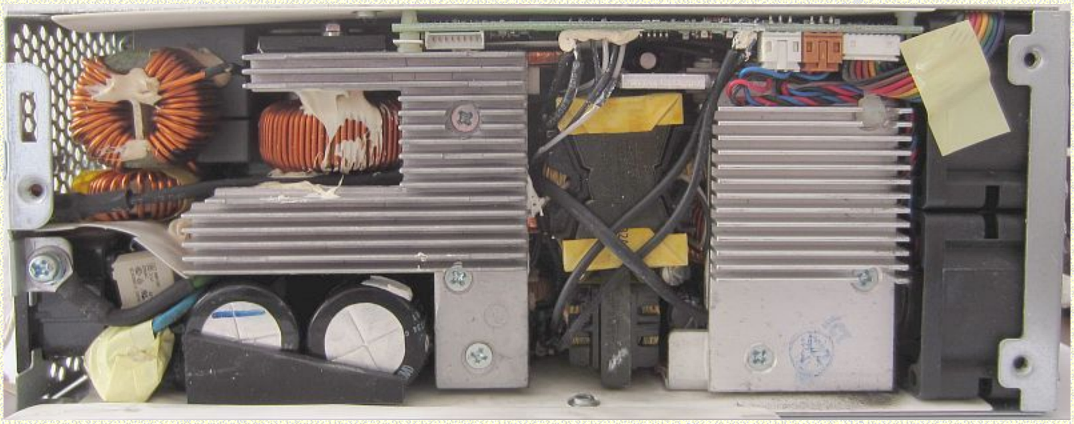
Server switching power supply 200-240 VAC/12.15 VDC/82.3 A. Size metal box (without projecting parts) is 21.5 × 8.5 × 5 cm.

INTRODUCTION

At flea market a server switching 12.15V/ 82A power supply was offered for about €20,-. Because it was pretty small and fairly to the price, I bought it out of curiosity. Searching for a schematic on the Internet was unsuccessful. The supply appears to be a common HP, Delta and Fujitsu model type DPS-800GB A. Also known as type ATSN-7001044-Y000 and type HSTNS-PD05.

INCREASE SUPPLY VOLTAGE

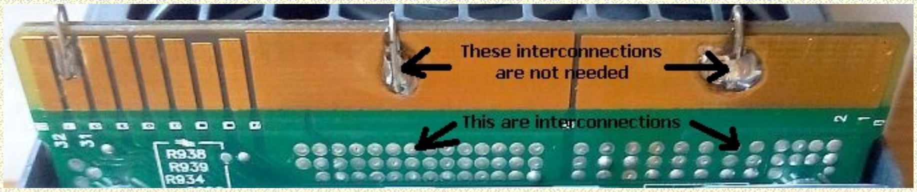
For hams a 13.8 Volt supply voltage is a more usual value than the preset 12.15 Volt. To increase the voltage about eight different circuits can be found on the Internet. Without a schematic it is almost a gamble to design the correct circuit. By measuring resistance and voltage between the tracks I have attempted to find out how it really works. Unfortunately, the puzzle is not solved.



Top view. Main PCB at the bottom.

With an internal potmeter at the main PCB the voltage can be changed, but therefore the very compact device must be completely disassembled. There was no enthusiasm to do it because literally every empty space is used to cram components.

Top and bottom pads.

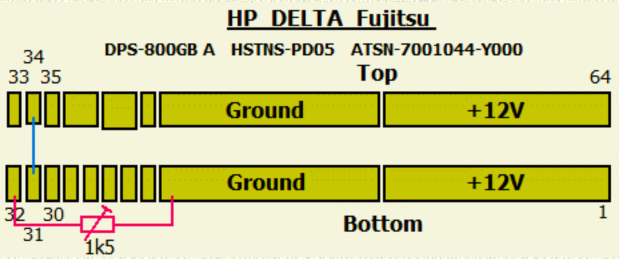


To boot: connect pads 34 - 31. (Large #Ground and #+12V pads are interconnected on the PCB).

On internet one can not find a schematic diagram. I have had contact with an employee of a company that repairs such PSU's, but the schematic may not be revealed. Probably because the manufacturer wants to avoid the solid PSU will be used for something else. Actually, without a schematic it is almost impossible to design a correct modification to change the voltage. Because pin 32 = remote sense and pin 33 = remote sense return, a satisfactory solution was found by trial and error.
(1) To boot: connect pads 34 and 31.
(2) Install a resistor between pad 32 and ground.

Start with a 1k5 variable resistor. Reduce the value for an increased voltage. At more than 13.8 Volts the PSU switches off when the load is removed. With connected load power can be turned on and due to the built-in soft start it does not switch off. That is important if one has connected a load such as a car battery.

The maximum current is dependent on the set voltage. With more current the supply swithes off. Under load (Vload) the voltage drops some milivolts.The foregoing is shown in the table.



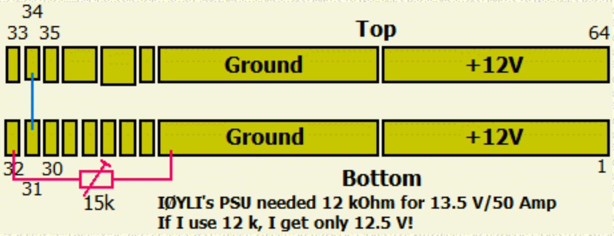
Set V	Vload	Max
13.0	12.75	85 Amp
13.5	13.26	55 Amp
13.7	13.50	45 Amp

OTHER VERSIONS

IØYLI wrote me that his version of the power supply needed 12 kOhm to obtain a higher voltage. His versions are:

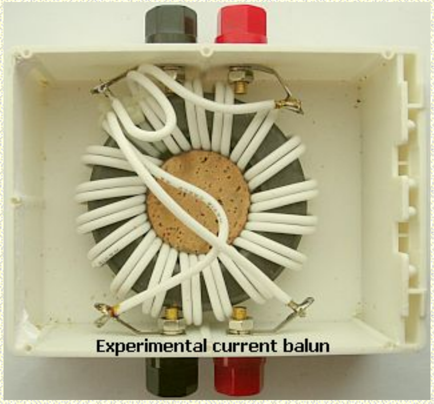
MODEL: DPS800GB A REV: 06M
HSTNS-PD05
p/n 379123-001

MODEL: ATSN 7001044-Y000 REV: 06M
serie HSTNS - pro1 BUILD: OC (o DC)
p/n 380624-001



A German ham had me already reported a similar action for increasing voltage. Apparently there is still a difference in the types of **DPS-800GB A, DPS-800GB 1A** and **DPS-800GB 2A**.

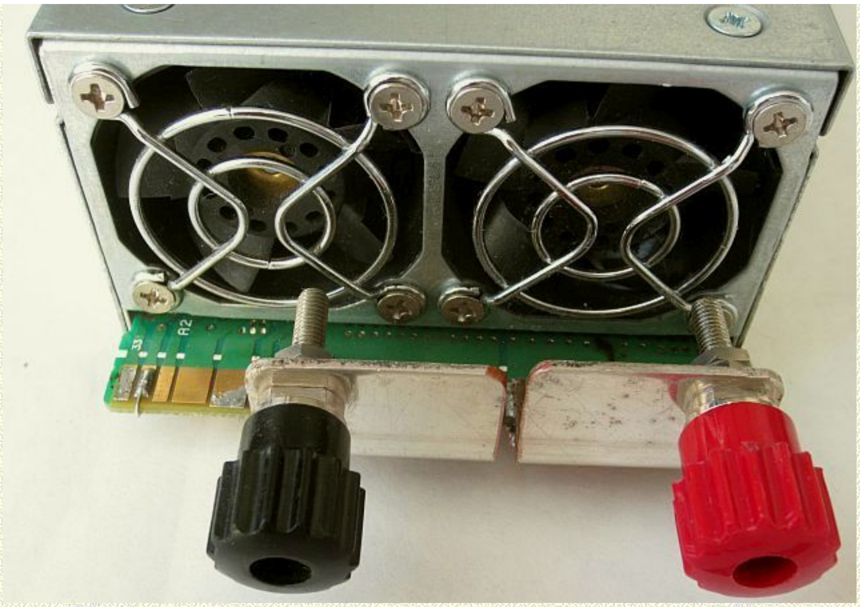
INTERFERENCE



The interference occurs every multiple of 70 to 100 kHz if the sypply is used for a transceiver. The frequency is voltage-dependent. Noise level at 160 m is strongest and it decrease at higher bands. At 20 meters, it is not so annoying.

It is not excluded that noise can be suppressed or eliminated with filters in feeding cables. For a test I temporarily used a current balun from an antenna system as suppression filter. The interference continued but was decreased so that receiving was not bothersome. Presumably a better suited filter will solve the problem.

DIY



Positive and negative terminals installed.

PCB's tracks of top and bottom, of respective #ground and #+12V are connected internally. Further the PCB has a conductive intermediate layer of the same polarity.

For practical use terminals are mounted on a brass hook profile wich is soldered to the top of the PCB. For better conduction the tracks on the bottom are soldered with copper foil to the bracket.

COOLING

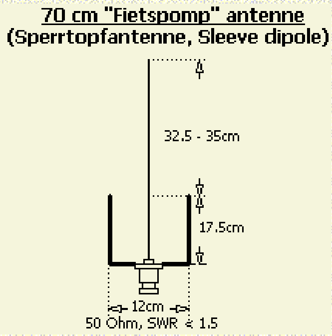
The two small fans make little noise and still works so well that during a ten minute load of 85 Amp the housing was only lukewarm. The power supply is a powerhouse in a very small size!

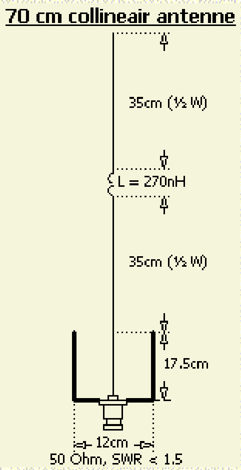
«Back AØFRI

70 CM OMNI SLEEVE ANTENNA

(FURTHER: COLLINEAR VERSION AND 2 m/70 cm VERSION)

Met een eenvoudiger collineair systeem.





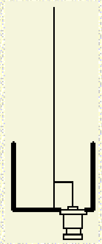
INLEIDING

Experimenteren met antennes is leerzaam, ook leuk om te doen en een handzaam formaat verkrijgt men door een hoge frequentie te gebruiken.

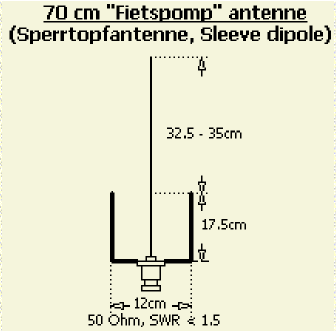
In een XENOS winkel zag ik toevallig een RVS lepelhouder met een geschatte lengte van 17 cm, een geschikte afmeting voor een 70 cm antenne. Later bleek het iets langer (178 mm) te zijn, maar goed bruikbaar om met een fietspomp antenne («fig Sperrtopfantenne, sleeve dipole) aan de gang te gaan. Overigens als men twee blikjes van 300 ml of 425 ml aan elkaar soldeert en van de bovenste eerst de bodem verwijdert, heeft men een "sleeve" van 17 cm.

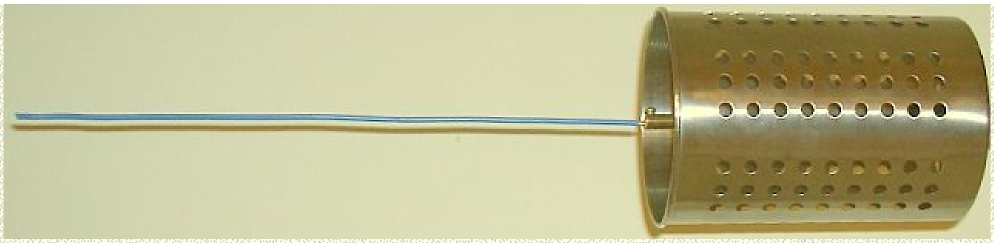
De RVS lepelhouder heeft mijn voorkeur omdat bij plaatsing buitenshuis het beter weerbestendig is en het regenwater door de gaten in de bodem leeg loopt. Het schijnt dat IKEA ook een assortiment RVS lepelhouders heeft.

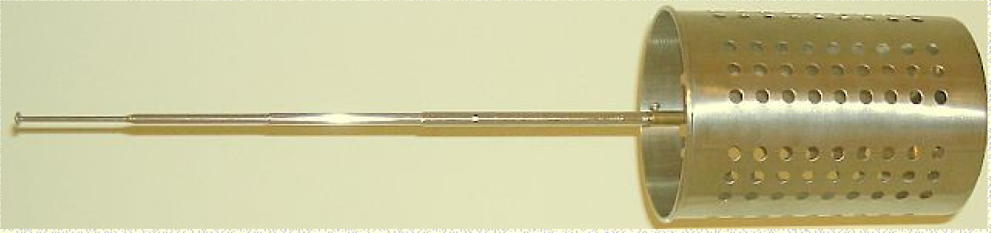
EXPERIMENTEN



Initially ("fig") experiments were done with a gamma match, but soon the idea came up to feed the antenna directly to see how the SWR would turn out. A blue, too long installation wire was soldered directly to the BNC chassis part. By cutting off half a centimeter each time the SWR went to a surprisingly low value. At a later stage, the wire was replaced by a telescope antenna of a portable radio, so finding the right length was much easier. Depending on the mechanical construction of spoon can with antenna bar or wire, chassis part and insulator, one can achieve SWR = 1.2 with an antenna length of 32.5 - 35 cm. It is not unlikely that you can even obtain SWR = 1.

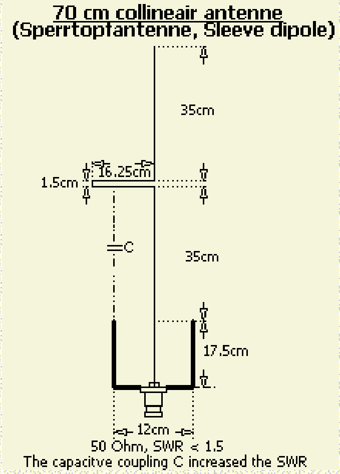




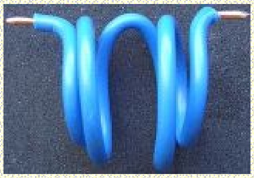


When testing with two counter stations and a number of repeaters, the antenna proved to work exceptionally well compared to a number of other self-built vertical antennas. In my opinion, there is a fairly flat all-round radiation due to the relatively large size of the spoon holder as a sleeve .

COLLINEAIR



Because I was curious about the effect or effect of a collinear system, we experimented («fig) with a ¼ wave hairpin to feed two ½ wave dipoles in phase. No sooner said than done, but unfortunately the SWR did not get any better! Changing the lengths of the dipoles also did not help to reduce the original SWR of the first Sperrelop antenna.

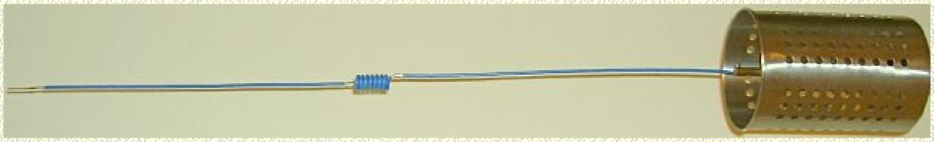


Also the "rolling up" (fig ») of the stub or hairpin did not bring any improvement and even extra work. The size was therefore electrically too long and had to be shortened to return to resonance.

Testing with a coil of blue installation wire as a phase turner was the next step. By means of a "cut and try" method, the correct inductance was found ("fig") to bring the matter into line. Rinse: 7½ turns around a 10 mm drill bit. As it turned out, the low SWR was back! That gave reason for thought, why was the SWR worse with the hairpin. Eventually I come to the following statement that I have not yet seen in other publications.

Conclusion: The hairpin increases the capacitance (C) to the reflective surface, changing the resonance or impedance of the antenna.

Antenna testing

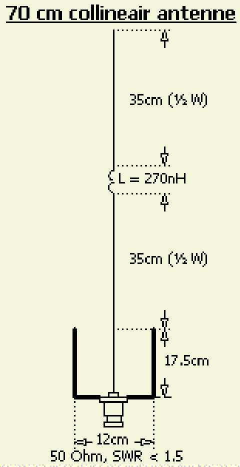


Phase 1.

Phase 2.

Phase3.

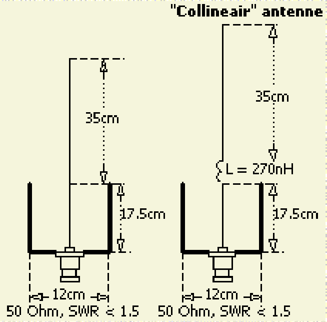
The wire was replaced by 1 cm Ø aluminum pipe .



The coil is made on a 10 mm drill bit with 2 mm Ø enameled wire, is 2 cm long and has 7 windings. The SWR can possibly be improved by stretching or compressing the windings. The two dipoles are glued around a fiberglass epoxy rod that the coil passes over. Finally, the construction was made weatherproof by covering with black shrink sleeve. Before doing so, the Alu tube was first provided with a layer of contact adhesive on both sides. As an extra, a few layers of black bumperspray (fig ») were sprayed onto the shrink tubing. This paint is intended for plastic bumpers. All my antennas are treated with this, because after years it has been shown that it offers good protection.

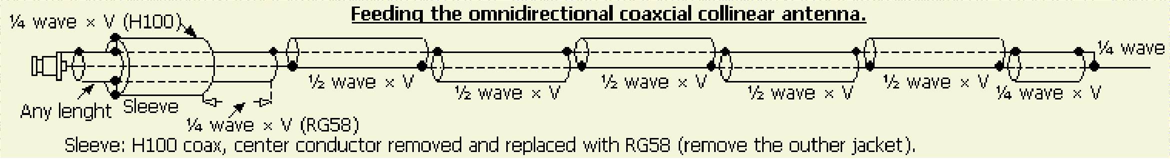
EASIER COLLINEAIR

Yet something else tried. The reasoning was that the spoon box as a muff (stub or "hairpin") is in fact a half wave folded element that emits little or no light. If the socket and the radiator are fed in phase, would the radiation be flatter? The coil was inserted in between as a phase shifter (fig ») and indeed it turned out that repeaters sent a weaker signal and distant repeaters became stronger. All this in comparison with the left-hand antenna. The result was actually very striking and comparable to the collinear (fig ») in the photo!

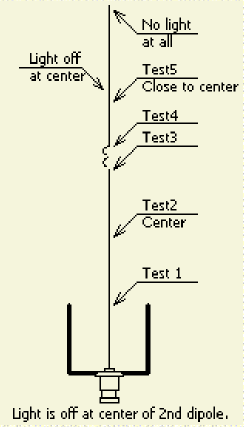


The middle and right antenna did it as well.

STRENGTHENING?



Following experiments with the collinear bicycle pump antenna and the above omni collinear, I have strong doubts about the "gain" that people claim for such ½ wave elements superimposed in series. What is the case? Each subsequent dipole receives its signal via the previous radiator, and that becomes less and less as a result of various losses. That can easily be demonstrated with a fluorescent fluorescent tube. This is significantly less with the second dipole and the grabbing of the third or next dipole has no effect on the SWR either. I think it is different if ½ dipoles placed above each other are fed separately.

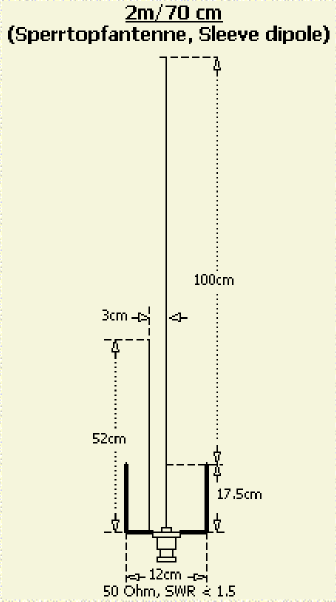


In the test setup shown here, you can see how the light output decreases as the fluorescent tube is moved upwards. There is a considerable difference between the coil below (test3) and above (test4). Even if one touches the top with a metal wire, the SWR hardly changes. In the middle of the upper dipole the light went out. The fluorescent tube could no longer be touched when the top of the antenna was touched.

The coil as phase turner actually works as a shortened ½ wave "dipole". The antenna can thus be regarded as three ½ wave elements connected in series.

Given the test results, I think more than two phase fed and serially connected ½ wave emitters contribute more to the probable theoretical claimed by strengthening manufactures and authors of such structures. This has also become apparent when the antenna has been expanded with a coil and a third ½ wave element.

A 2m / 70cm MODEL



One can make a two band antenna with the spoon tray for 2 m and 70 cm. There are several possibilities to do that, but when testing a number of combinations, I found that the illustrated version ("fig) worked best. At 70 cm it is a Sperrtopfantenne and at 2 m a J-antenna. For a low SWR on both bands, one has to experiment with the length of the left 52 cm "leg" (of the J-antenna), because the specified measurements are still of the test model. It turned out that the institution was rather critical with a change of 5 mm.

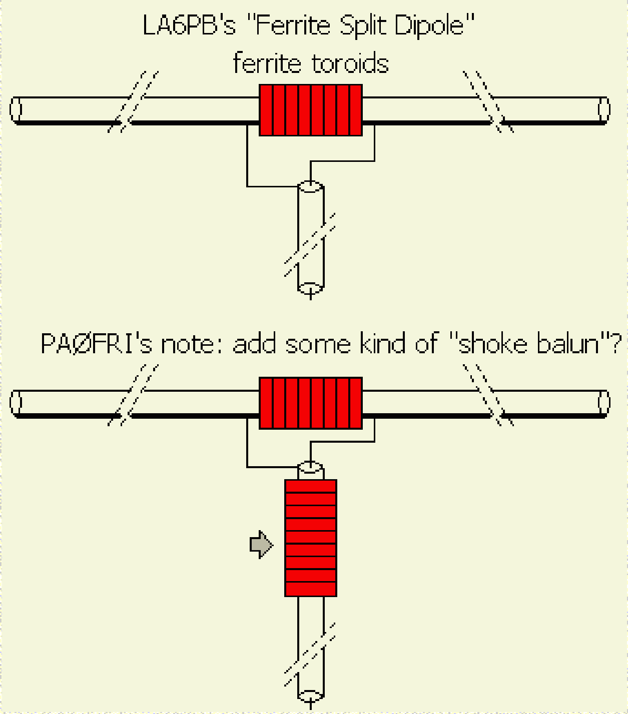
A 2 m / 70cm attempt with the previous 70 cm collinear antenna did it but was not so good at 70 cm.

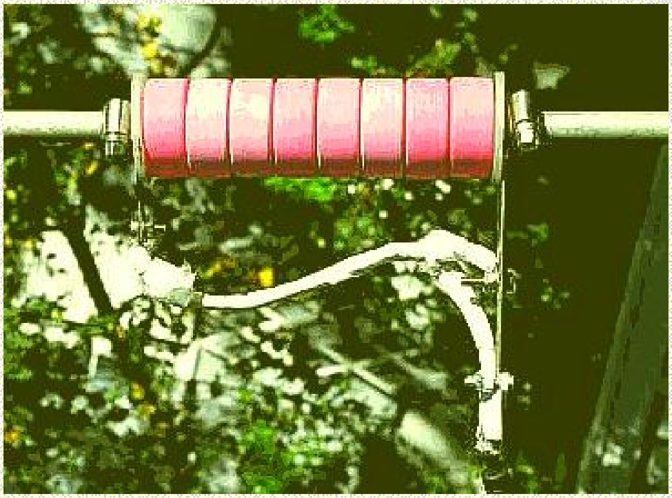
« Back

LA6PB's SPLIT DIPOLE

A new method of feeding a dipole with toroids.

UPDATED **8 Aug 2015 More info about the ferrite beads.**





LA6PB calls his idea "Split Dipole"

INTRODUCTION

The well known ferrite bead sleeve balun was introduced by W2DU, W. Maxwell. (QST March 1983.) I have this balun installed on all my coax feeders. One day it occurred to me that these ferrite beads could be used to split a conductor and thereby create a dipole.

A quick experiment confirmed my assumption: 50 Amidon beads no. 73 were strung on the centre of an approx. 5 m long wire. The ubiquitous MFJ SWR-meter was connected to each side of the bead sleeve, and indeed right, showed resonance and a low SWR. What practical use could this discovery lead to?

EXPERIMENT

Some time ago I was given a solid aluminium rod, 4.66 m long and 12 mm diameter. From an old TVI problem I had some ferrite toroids, type Philips 4330-030-3445, OD/ID: 36/21 mm, W: 15 mm. I am convinced that you can get similar toroids in EU and the US, anyhow, you may try whatever you have in your junk-box.

I put 5 of these ferrite toroids at the centre of this Al-rod, and placed the rod 2 m above ground. Again the theory was confirmed; I found resonance at 28,4 MHz.

The transmitter was connected to the antenna. With an output of 200 W there was very little heating of the toroids, but with 500 W the toroids became a little warm.

The number of toroids were increased to 8 (schematic), then there was no heating at 200 W, and a very modest heating at 500 W after some minutes key down.

CONSTRUCTION

The toroids were mounted with some insulation on the rod, so that they sit tight, and a plastic wafer at each end. Two stainless steel hose clamps hold two right angles bent stainless strips to the rod, and the coax, properly sealed against water is connected to the stainless strips. The coax itself is clamped to one of the strips. See the photo.

After these tests I climbed a pine tree and mounted the aluminium rod horizontally ca 10 m above earth, taped to two branches on each side of the toroids.

RESONANCE

The resonant frequency was now found to be 29.2 MHz, but the SWR curve was so flat that I measured:

28 MHz	SWR = 1.2
29.2 MHz	SWR = 1
29.7 MHz	SWR = 1.1

Both my transceiver and my transistorised 500 W PA give full power over the whole 10 m band without use of the build-in antenna tuner!

From earlier experience I know that ferrite beads are not subject to corrosion. I have had beads exposed to outdoor weather for years without any sign of corrosion. This new antenna with the toroids has now survived two years without any problem.

What was meant, as an experiment has become a permanent antenna.

ADVANTAGE

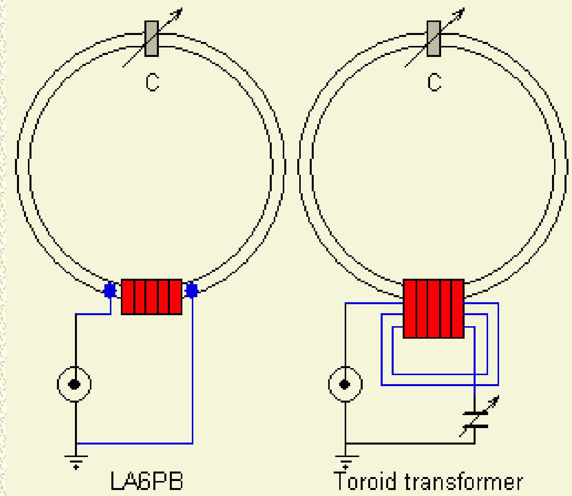
What is the advantage with this "Ferrite Split Dipole"?

After installing the toroids, there is no need for any post-installation and
adjustments compared to gamma, T-match or other matching methods.
Mechanical strength, only one solid rod or tube.
Suitable for one single support can easily be rotated.

PERFORMANCE

Then the inevitable question: How does this antenna perform on the air? In the CQWWCW contest Nov. 2000, I worked 70 countries on all six continents with 100 W. I am very pleased with this antenna.

John Lien, LA6PB, lien.j@frisurf.no



NOTE (PAØFRI):

Left figure: His idea can be used to feed a magnetic loop antenna.

Right figure: A couple of toroids as transformer to match the low impedance of the loop to 50 Ohm. Eventually with an extra loading capacitor for easy matching.

TOROID

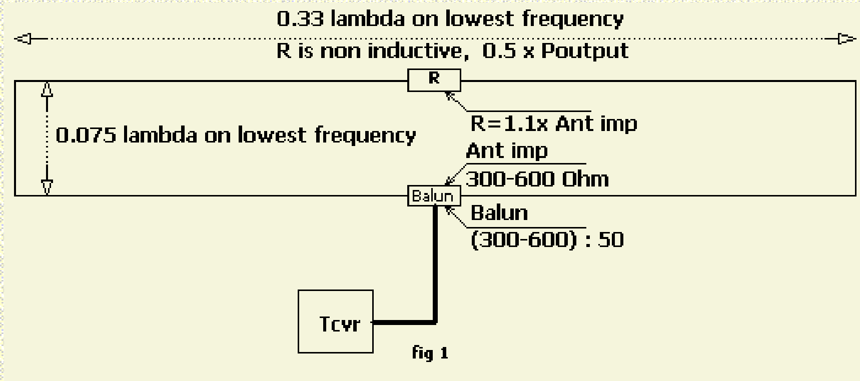
PE1ABR provided more information. The Philips 4330-030-3445 toroid is also know as rose 36 mm dia type 4A11. An Amidon compatible type is FT140-43.

«Back PAØFRI

T2FD = Terminated Tilted Folded Dipole

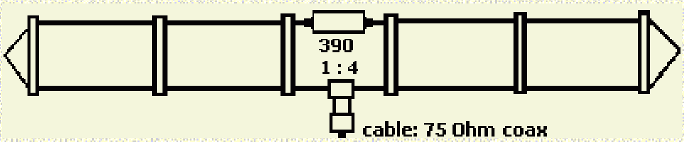
T2FD

A T2FD was originally a broadband antenna for receiving broadcasting stations, but was used as an antenna for military transmission systems in the 1960s. Currently, the antenna is now widely used by fixed stations of aid organizations such as UN, UNHCR, Red Cross, Doctors without borders etc. Usually their antenna is a B & W broadband antenna. The wingspan is 1/3 wavelength at the lowest frequency.

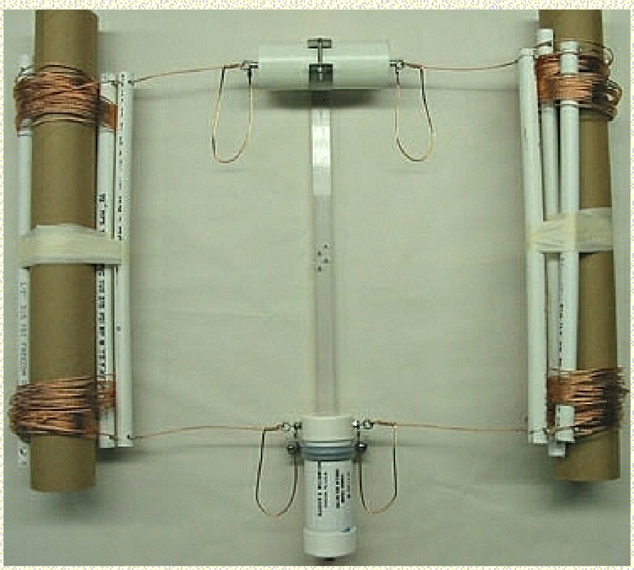


T2FD (Terminated tilted folded dipole)

DESCRIPTION



A T2FD is a non-resonant folded dipole that is sealed with an induction-free resistance (dummy load). There are running waves, part of which is absorbed by the resistance. This results in a broadband effect and the possibility to feed with a coaxial cable. All properties mentioned were attractive to military personnel and therefore they also adopted the system as a transmitting antenna.



A broadband (= T2FD) from BARKER & WILLIAMSON.

Food can be done with an open line, but that does not occur in practice with the aforementioned organizations. Because the SWR is not higher than about 3, the tuning takes place with an automatic antenna tuner via a coaxial cable (75 Ohm) to an HF balancing transformer (balun 1: 4) in the feeding point. If the antenna is set up, it can be used immediately for a very wide frequency range.

In addition to B & W, such an antenna is also supplied by other manufacturers (fig »).

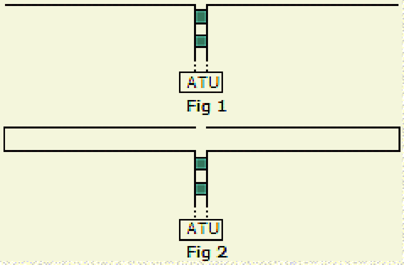
PRACTICE TEST

In the period 1970 - 1972, several tests were done by myself in Ermelo with a home-made T2FD and it quickly became clear that it was not such a perfect antenna for our amateur amateurs. The SWR varies quite a bit over the range. There are points where that is low, but elsewhere also quite high. With a tube transmitter that is still catchable, but with a modern transceiver is really a (built-in) antenna tuner needed.

Test with 1 × 680 Ω or a number of parallel. With 100 W, this resistance finally changed: warm = 460 Ω and cold = 496 Ω, why ? of the input power!

It is claimed in publications that the resistance (fig ») must be suitable for one third (1/3) of the transmission power . That is an optimistic claim, because in me various resistances have changed due to overheating. Also remember that in the sun an object can reach a temperature of more than 60 °. My conclusion is that the resistance must be able to handle at least half (½) of the transmission power (ouput).

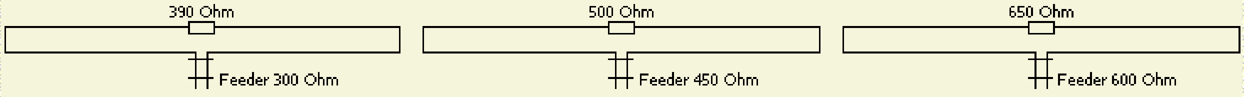
The efficiency of the antenna in the low frequency range is also less than a full-size dipole. I estimate that it saves about one S point to the detriment of T2FD. If a T2FD (fig 1 ») is replaced by a dipole of the same span and is fed with an open line and tuner, then on average that gives a stronger signal. Such an antenna type is easier to place, is less noticeable and your neighbors will probably have less objection or no longer



nagging! It is even better to replace the resistance with an insulator (fig 2 »). As far as I can remember, there are two publications from an American and English university in which the researchers reported disappointing results and certainly would not advise a T2FD system when it comes to an optimal signal.

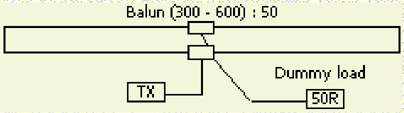
Following this article, a couple of fellow radio amateurs have emailed me that they have achieved a good result with this antenna. It is possible that you get an S9 report at 80 m and are satisfied, but with an ordinary dipole the report probably had S9 + 6dB under the same conditions!

RELATION RESISTANCE AND POWER SUPPLY



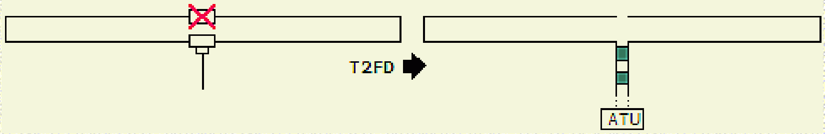
It has not been tested by me, but the value of the resistor seems to be quite critical and is determined by the impedance of the connected power line: 390 Ω for 300 Ω ribbon line, 500 Ω for 450 Ω ribbon line and 650 Ω for a 600 Ω open line .

OTHER CONSTRUCTION



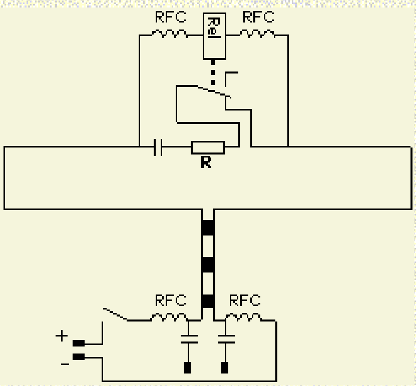
Affordable resistors from 300 to 650 Ω for good power are no longer easy to find. A more practical construction (fig ») is obtained by replacing the resistance with a balun that transforms the high impedance down to 50 Ω . A dummy load can then be set up at a suitable location to capture the power via a thin, cheap 50 Ω coaxial cable. A loss-free cable does not have to be necessary because damping features are even an additional advantage here!

ADVICE



If you have a good symmetrical ATU and the antenna can be fed with an open line, then there is no reason to use a T2FD. A better antenna is obtained according to the left-hand drawing. The resistance of a T2FD is removed and replaced by an insulator.

With an antenna of about the same wingspan as a G5RV you will generally get a better result than with a T2FD.



Nevertheless, I do not want to stop you from experimenting with this broadband antenna.

It was asked how the resistance can be switched off to choose between a T2FD and an open dipole. You can see a principle diagram in the drawing next to it. The relay must be suitable for a high voltage and for the capacitors one chooses types that can withstand a large RF current and voltage.

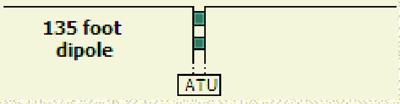
PRACTICAL EXPERIENCE

NL7W (eHam.net 9 Sep 2007)

I unfortunately used these for years in USAF, all because the average (non-ham) radio operator and maintainer did not have a clue regarding antenna characteristic trade-offs and efficiency. The military keyed in on their simplicity or ease of use. It was "magical" to them ...

In contrast, the terminated, tilted, folded dipole, T2FD, is a very poor antenna, typically several dB down from a similarly mounted resonant dipole. Performance is sacrificed or traded for its broadband characteristics.

As hams, I believe we are challenged to learn, install, and upgrade our stations and antenna systems. Operating one of these poor, yet broadband, performers goes against the grain, so to speak.



A simple upgrade from this poor performer would be a 135 foot dipole fed with open wire, with a solid tuning antenna tuner (able to efficiently transform balanced to unbalanced RF) near the rig, thus reducing losses to a bare minimum. This far more efficient antenna system would cover roughly the same frequency range, if not more, and offer modest signal enhancement, to include gains over a dipole on higher frequencies.

PAØFRI: Obviously, I fully agree with him. (Of course, I fully agree with him.)

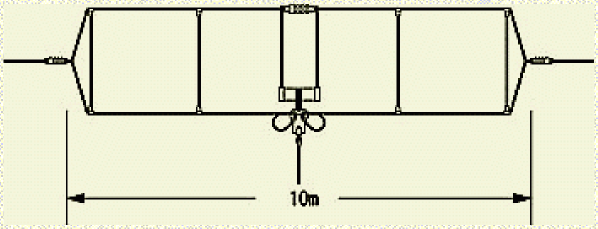
N0YG (8 oct 2007)

I installed the BWD 90 on the roof of the school this summer. The SWR are at 2.0-1 and on 40 meters they are 3.9 across the band. I bought this antenna because of the "NO NEED FOR A TUNER" advertisement, what a joke. I would not advise anyone to buy such a worthless piece of ****. Enough said.

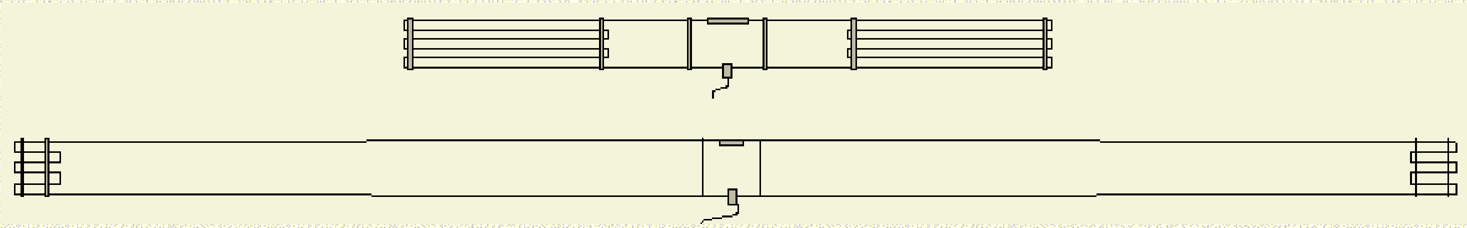
ANTENNAS WITH THE SAME PRINCIPLE

DIAMOND

Diamond has included such an antenna as DIAMOND WD-330S in its range of products.



RADIO WAVZ



Variable Folded Terminated Dipole.

The RadioWavz VFTD series terminated folded dipole is a broadband antenna designed for fixed station, multi-frequency applications. The antenna can be mounted horizontally between two support systems, or as an inverted 'V' using a single central support mast. This antenna type is widely used by military, commercial and broadcasting services. The VFTD antenna line is made with extremely durable UV insulated stranded flexible wire. The VFTD series is designed to allow for variable site installation, to maximize available space.

Specifications: VFTD 60 **Impedance: 50 Ohm nominal**

Bandwidth: 3.5-30 MHz,

Length: 65ft. (19.8m)

Power: 1.5kw Impulse

: 500w PEP SSB

: 200w AM / FM / RTTY

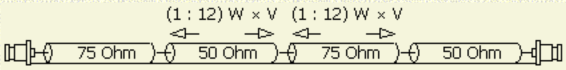
Connector: SO 239

«Back AØFR

MATCHING WITH $\frac{1}{12}$ λ (WAVE) TRANSMISSION LINE

12 dec 2014 With PEØHZD's calculation..

INTRODUCTION

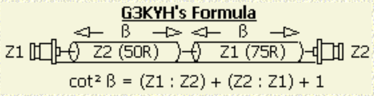


Matching with a ¼ wave or ½ wave coaxial cable is pretty well known, but an existing 1961 system to do that with two one-twelfth-wavelength transmission lines, has not yet become common practice in many countries. This article is intended as additional attention.

SYSTEM

The system is based on a complex formula L = [arctan(sqrt (B/(B ^ 2 + B +1)))]/(2.pi), B = Z1/Z2, that can be found on the Internet together with the associated graphics. For the DIY builder the graph below is clearly enough to get started. The adjustment is quite wide-band and in principle coaxial length of one-twelfth wavelength should be sufficient, but according to the formula the matching is optimum if the length is calculated on the basis of the transformation ratio.

G3KYH's FORMULA



Leafing through my archives, I found a simple trigonometric formula derived by G3KYH, which one is able to handle well in practice. It was published, I think more than 35 years ago in Technical Topics of the English RSGB. The calculation is done in degrees and 360 should divide the outcome.

If you are like me have not "played" with trigonometry for about 50 years, you will still need to refresh your memory! Fortunately it is easy counting (after some practice) with a modern electronic pocket calculator.

Later I discovered a program on the Internet that calculates the degrees: http://leleivre.com/rf_bramham.html

But still commence some practice with the calculator.

Suppose we want to match: 75 Ohm » 50 ohms, then

cot ² ß = (75: 50) + (50 75) + 1 = 3.167,

cot √ ß = 3.167 = 1.78 (on the calculator we enter 3167 and √)

because cot ß = 1: tan ß,

thens tan ß = 1: 1 cot ß = 1.78 = 0562 (the calculator divides 1 by 1.78)

tan -1 = 29 336 ° (type 0526, shift and tan $^{-1}$).

If we only focus to the calculator, see the following steps:

(75 : 50) + (50 : 75) + 1 = 3.167,
type on the calculator 3.167 and √,
= 1.78
on the calculator devide 1 by 1.78
= 0.562
type on the calculator 0.526, shift and tan $^{-1}$,
= 29.336°
on the calculator devide 29.336 by 360,
= 0.0815

The length of the coaxial cables is 29.336 °(degrees) that is a portion of a 360° angle.

The electrical length L of the coaxes is 29.336: 360 = 0.0815 λ (wavelength, lambda or Wave)

The physical length L is 0.0815 × W × V (velocity factor of the cables).

I rounded the numbers after the decimal point for simplicity of the example.

PEØHZD

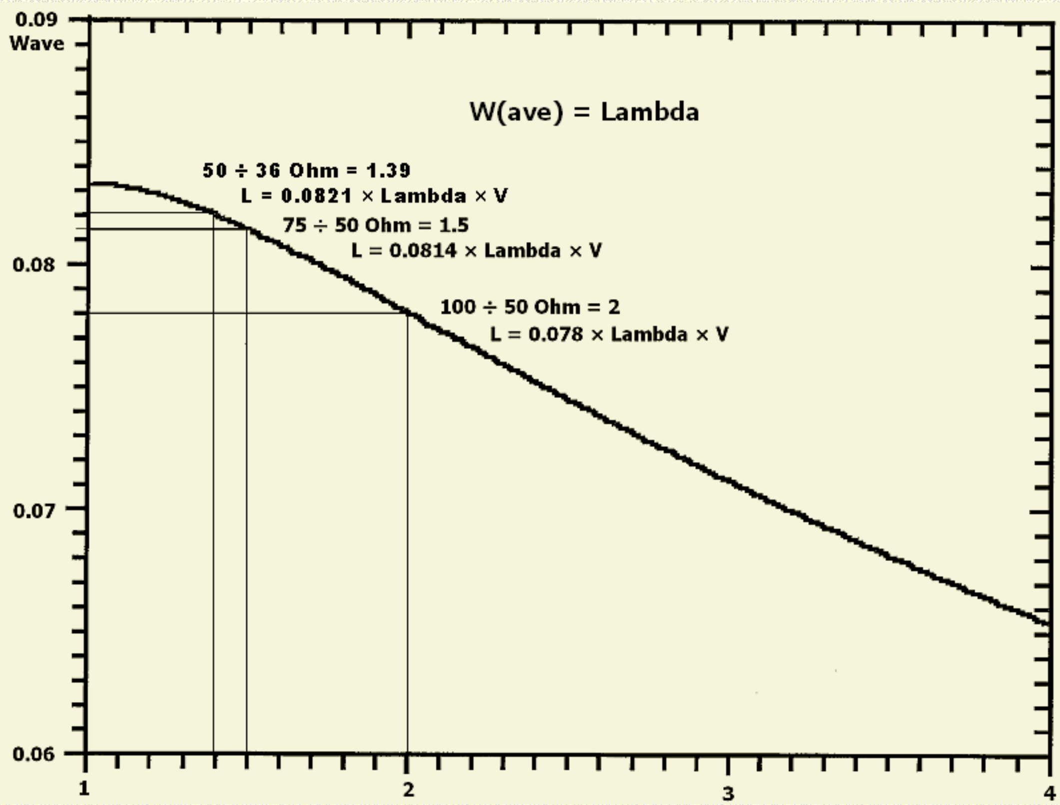
PEØHZD made some calculations, and is write in this table.

PEØHZD's calculation

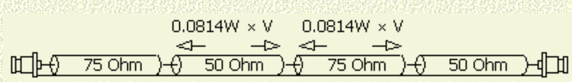
Z1/Z2	x	Degree	Lambda	Z1/Z2	x	Degree	Lambda	Z1/Z2	x	Degree	Lambda	Z1/Z2	x	Degree	Lambda
1,1	0,5765	29,9625	0,0832	2,1	0,5288	27,8698	0,0774	3,1	0,4755	25,4317	0,0706	4,5	0,4180	22,6869	0,0630
1,2	0,5742	29,8631	0,0830	2,2	0,5231	27,6140	0,0767	3,2	0,4708	25,2088	0,0700	5,0	0,4016	21,8809	0,0608
1,3	0,5708	29,7178	0,0825	2,3	0,5174	27,3592	0,0760	3,3	0,4661	24,9902	0,0694	5,5	0,3869	21,1494	0,0587
1,4	0,5667	29,5384	0,0821	2,4	0,5119	27,1064	0,0753	3,4	0,4616	24,7759	0,0688	6,0	0,3735	20,4829	0,0569
1,5	0,5620	29,3339	0,0815	2,5	0,5064	26,8563	0,0746	3,5	0,4571	24,5659	0,0682	6,5	0,3615	19,8729	0,0552
1,6	0,5568	29,1111	0,0809	2,6	0,5010	26,6092	0,0739	3,6	0,4528	24,3602	0,0677	7,0	0,3504	19,3124	0,0536
1,7	0,5515	28,8752	0,0802	2,7	0,4957	26,3657	0,0732	3,7	0,4485	24,1586	0,0671	7,5	0,3403	18,7954	0,0522
1,8	0,5459	28,6304	0,0795	2,8	0,4905	26,1260	0,0726	3,8	0,4444	23,9611	0,0666	8,0	0,3310	18,3167	0,0509
1,9	0,5402	28,3797	0,0788	2,9	0,4854	25,8904	0,0719	3,9	0,4404	23,7677	0,0660	8,5	0,3225	17,8720	0,0496
2,0	0,5345	28,1255	0,0781	3,0	0,4804	25,6589	0,0713	4,0	0,4364	23,5782	0,0655	9,0	0,3145	17,4576	0,0485
												9,5	0,3071	17,0702	0,0474
												10,0	0,3002	16,7071	0,0464

GRAPHICS

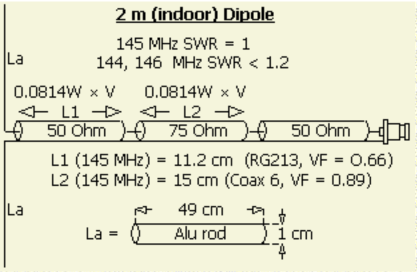
Using the graph is simple and will satisfy in practice.

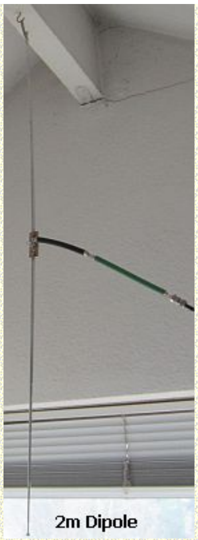


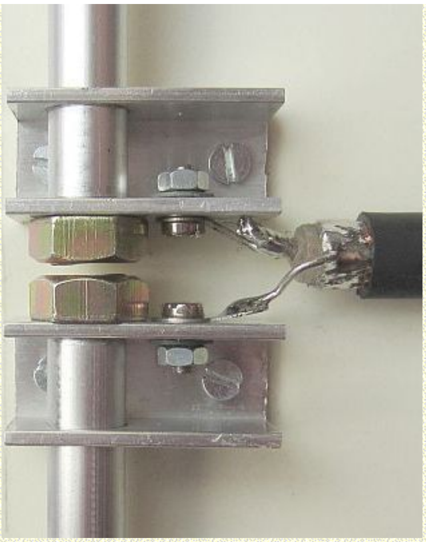
EXAMPLE 75 Ω » 50 Ω



If one wants transfer 75 ohms impedance to 50 ohms, that is a ratio of 75 ÷ 50 = 1.5. According to the graph it is a wavelength of 0.0814 (W)ave. The actual length of the coaxial cables dependent on the velocity factors (V) and is then: 0.0814 × W × V.



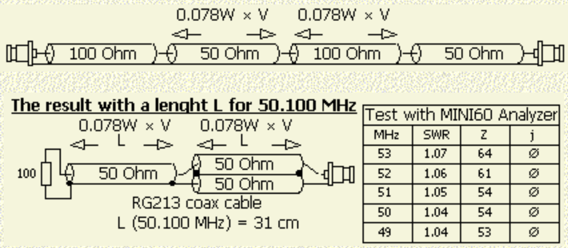




OK1AMF

OK1AMF use this type as outdoor verticale dipole, see http://ok1amf.nagano.cz/konstrukce/Dipol144MHz/Dipol_2m.htm

EXAMPLE 100 Ω » 50 Ω



Test with MINI60 Analyzer

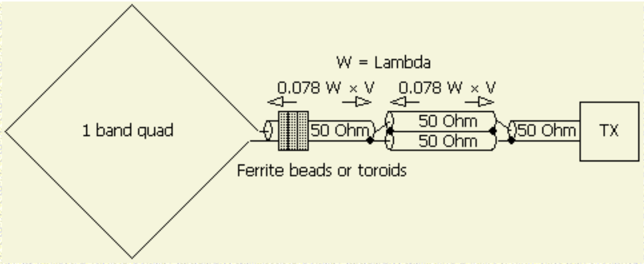
MHz	SWR	Z	j
53	1.07	64	Ø
52	1.06	61	Ø
51	1.05	54	Ø
50	1.04	54	Ø
49	1.04	53	Ø

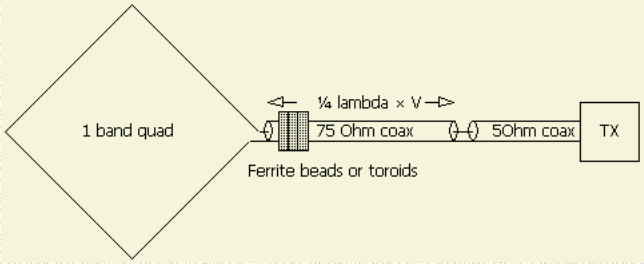
The transformation is 100 ÷ 50 = 2 the graph shows 0.078 wavelength.

The actual length is 0.078 × W × V.

A coaxial cable of 100 ohms is obtained by connecting like («fig) the right figure e.g. two 50 Ohm cables in series. Do not forget to solder the screens together on both sides. Additional advantage is one has to deal with only one cable type.

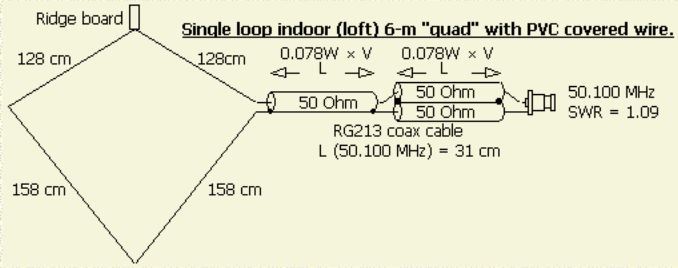
The length of the cables has been calculated for 50.100 MHz. The table shows the SWR if an induction free 100 Ohm resistor is matched to a 50 Ohm impedance. The system is clearly broadband! The conclusion could be that one does not need too accurate calculation.





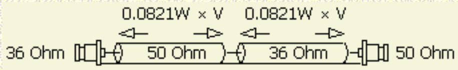
TEST ON 50 MHz

I regularly experiment in the attic with antennas including the 6 m band.

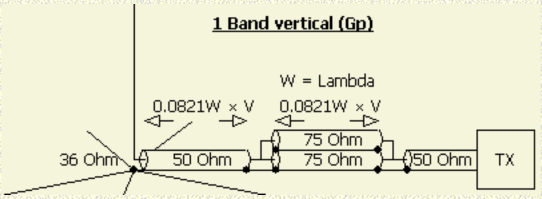


An at the ridge board («fig) hanging 6 m single loop made of insulated wire was also tested with the system. The SWR = 1.09 at 50.100 MHz is not wrong one would say in eastern part of my country. You may counter with other values because my antenna is the result of a variety of conductive materials in the vicinity and the velocity factor of the insulated wire. It's amazing what I can work in Europe with only 10 W and this antenna.

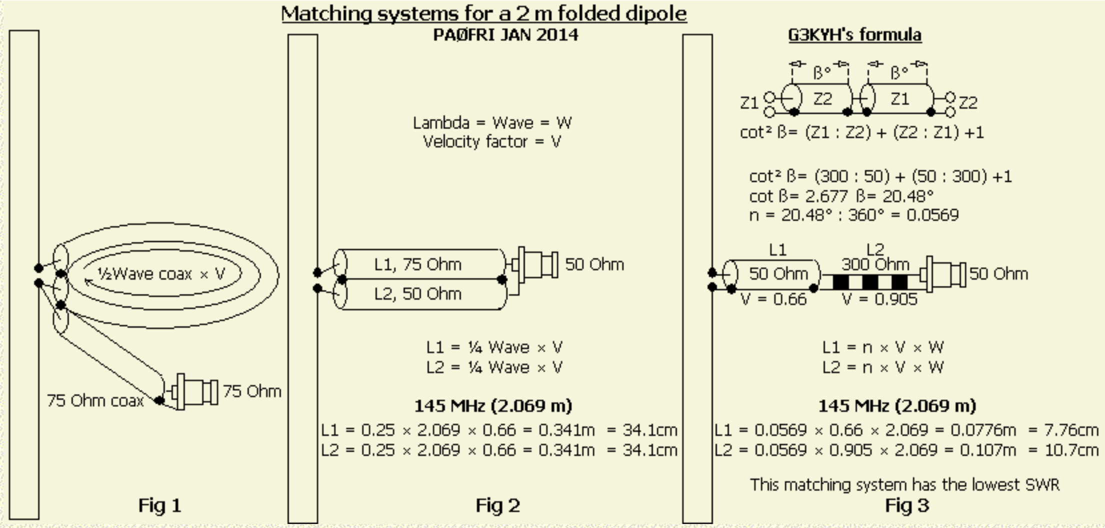
EXAMPLE 36 Ω » 50 Ω



Here we match 36 Ohm of a vertical antenna (Gp) to 50 Ohm. If we consult the graphics with the division of 50 ÷ 36 = 1.39 ohms, we find 0.0821 × W. The actual length of both coaxes is 0.0821 × W × V. A coaxial cable with impedance close to 36 Ohm (fig ») is easy to manufacture by paralleling (fig») two 75 Ohm cables.



EXAMPLE 300 Ω » 50 Ω

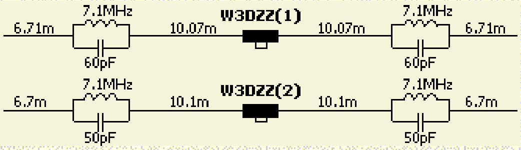


The figure shows that there are several options to customise. To test the system the antennas were alternately hanged at the ridge board. Recall that the results in free field can turn out differently.

« Back

Sparring (Staircase) for a W3DZZ Antenna

UPDATE T ext and schemes have been modified or extended, is added a ON9CVD stage antenna.



G8KW

The idea of parallel circuits or traps in a dipole antenna to obtain more than one resonance was first conceived by G8KW. He was assigned to the English Liaison Service as a soldier during the Second World War. His proposal was applied to military transmitting installations.

Through a publication of W3DZZ in a magazine for radio amateurs, the smart antenna system is therefore known as W3DZZ antenna.

It is a tuned circuit with coil and capacitor. Because the circuit is in parallel resonance (7-7.1 MHz), a high impedance of 40 m is created. The part of the antenna between the traps is insulated and the rest of the antenna has a negligible influence on 40 m. In practice it appears that the size of the piece between the traps is not too critical because the parallel circuit draws, as it were, the antenna part between the traps in resonance.

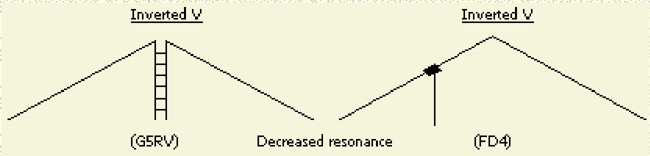
On a lower band the capacitor does not join, but only the coil ensures inductive elongation so that the antenna also resonates in a lower band. By extending or shortening the outer pieces, you can obtain a resonance of your choice in the 80 m band. Often there are also resonances in the 10, 15 and 20 m bands due to an (accidental) shortening effect of the capacitors. With these three bands the SWR can reach SWR = 2.5.

ADVANTAGE W3DZZ

An advantage of this type of antenna is that for 20, 40 and 80 m the point with the most current and maximum radiation is exactly in the middle and not somewhere in the power line. In terms of SWR, a G8KW / W3DZZ antenna is strongly influenced by suspension height and local conditions. Therefore, it may be necessary at a different location or suspension height to trim the length of both halves to obtain a low SWR on one or more bands.

DIMENSION OR SHAPE

Always keep in mind that specifying measurements of antennae in articles is a guideline. The actual electrical length depends on construction and environment such as: the power supply line, the thickness of wire, insulation on the conductor, the way of attaching to baluns or isolators and the capacity of the antenna with respect to "earth" and conductors. such as (wet) vegetation, antennae, fencing, balconies, concrete bars, electrical cables and other metal structures on or in the ground. You are lucky if an antenna does it in your situation as described by an author or manufacturer, but more often you will have to experiment or adjust in order to achieve optimal results locally for a good adjustment.



If a stretched (in-line) antenna is used in another form, for example inverted V, the capacity of the ends to earth increases. The antenna (eg a G5RV or FD4) is electrically longer and strictly speaking is no longer the same as the original. There is a big chance that the SWR is different on a number of bands.

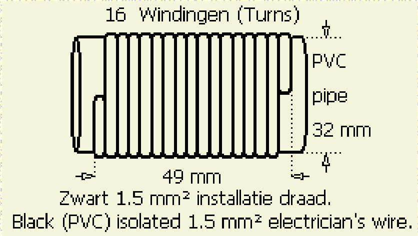
CONSTRUCTION

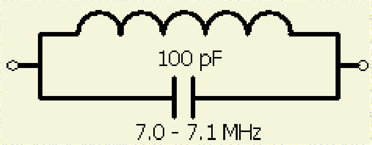
A 7 MHz lock circuit can hardly be adjusted properly without a suitable device such as a dipmeter. Many such circuits have been made here, and one of my products has determined that it also goes with just black installation wire (VDE 750 1.5 mm²). It then becomes easy for everyone to copy it without a measuring instrument.

If 16 turns of that wire are placed tightly together, this coil with a 100 pF capacitor resonates exactly in the 7 - 7.1 MHz range. The coil is 49 mm long and wound on a standard thick-walled type PVC tube with a diameter of 32 mm.

An HV "ton" capacitor.

Easy to make solid locking rings made of standard PVC material.





The photos clearly show how my practical execution was made. The spool shape is glued to the lid and the ends of the stairs are attached to a (Fritzel) insulator with two stainless steel bolts. The bolts are also connection points for the antenna. The capacitor is a Russian 100 pF / 10 kV type that is still offered on flea markets. There is also a usable smaller 100 pF / 7 kV of the same make.

The housing is a piece of PVC pipe with two lids. In the upper lid is the staircase and the bottom lid (bottom) is glued together and forms one whole with the pipe. The latter part is attached to the upper lid with two stainless steel bushes. One of the parkers is just visible on the top right. This creates a drip-water-tight construction that can be quickly disassembled for inspection and cleaning. The exterior has been painted with black "bumper paint" for plastic car bumpers and that is a very good weather-resistant treatment.

An antenna always hangs and the box is also skewed. In the lowest point a 4 mm hole was drilled in the bottom close to the edge to drain condensation water. At first it was left behind and it turned out that after a while a fair amount of water was collected. Unfortunately, that hole is big enough to offer all kinds of insects a safe shelter ("fig"). That is why it is wise to carry out an inspection after a number of years.

PAØHRA has recreated these lock rings (fig ») with a type of" ton "cap that is very popular with radio amateurs.

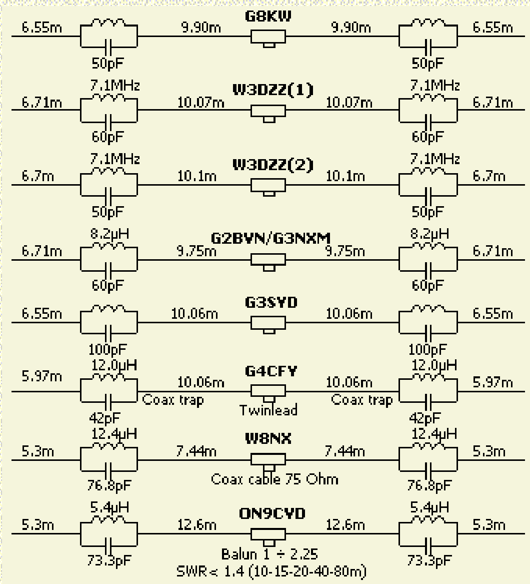
This model usually has a working voltage of about 1000 V. For a transmission power of up to 400 W, it seems to me okay, but for more output it is better to take a type with a higher working voltage. Also a piece of coax cable of about 1 m is suitable as 100 pF capacitor and that can endure a higher working voltage.

POWER

In experiments, the homemade locking rings in an antenna were regularly loaded with about 800 W and this had no adverse effect on the entire structure. You can see that on the photo of the cracked housing. Probably the stairs an even higher power because that is here a few times for a short time tested with 1.5 kW.

OTHER EXECUTIONS

Several amateur amateurs have tried, by changing the size and / or stage, to design an antenna that would resonate on more than two bands (fig »). You can also experiment with other lengths. Also read my article Dipool or start with G3SYD's antenna, for example.



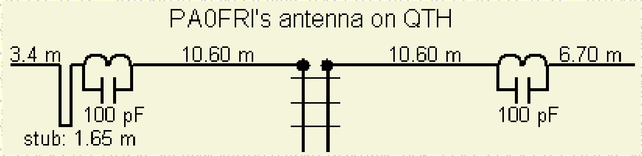
W8NX for 10-17-40-80 m

W8NX's developed an antenna for the American frequency segments 3.5 - 4.0 MHz and 7.0 - 7.3 MHz, 18 MHz and 28 MHz. The special feature of the design is the other location of the traps tuned to 5.16 MHz ± 25 kHz. A low SWR was at 3.8, 7.12, and 28.4 MHz and SWR = 3 over the entire 17 m band. The antenna was suspended as inverted V and fed with 75? coaxial cable and a 50: 75? balun. According to him, the antenna also worked with 50? coaxial cable and 1 ÷ 1 balun, but with the previous feeding mode the SWR was better at 18 and 28 MHz.

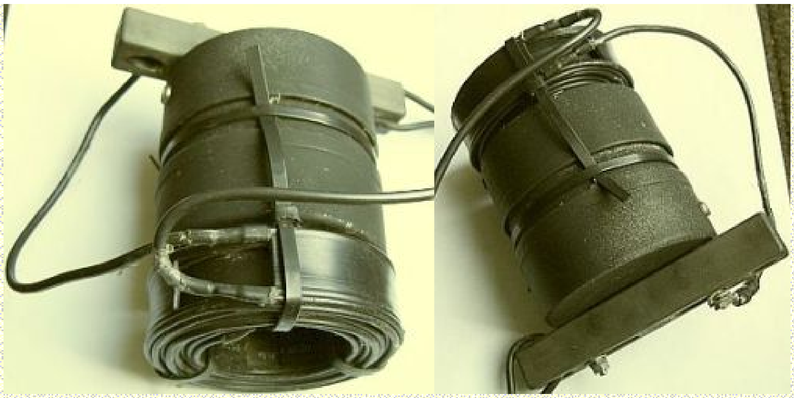
ON9CVD for 10-15-20-40-80 m

ON9CVD has also developed a number of antennas where the location of a staircase was also installed in an unusual place. The description of his systems can be found on:

http://sharon.esrac.ele.tue.nl/~on9cvd/Multiband%20trap%20antenne.htm



Because here the stepped dipole was fed with an open line, the dimensions were not so critical for me. For your information: the antenna hung as



inverted V on a mast of 12 m and the pieces of wire were 2 × 10.6 m (½ λ on 40m) and 2 X 6.7 m. In my backyard there was too little space and therefore a part of a dipole half with a rolled ribbon line (stub) extended. This antenna system was resonated on all 9 HF bands using a symmetrical tuner.

FRITZEL TRAPS

W3DZZs from FRITZEL.

Fritzel has had antennas with two types of locking rings in production. Top left the old type with a balun of white coax cable and top right with a ring core balun. On the bottom pictures the antenna with a newer model balun of series 83. Locker rings and balun are suitable for larger transmission power.

In the course of time a number of FRITZEL locking rings were "collected" and this made it possible to investigate the construction and value of the components.

Left: the construction and construction of an original FRITZEL staircase; right: a complete staircase without caps.

The measured values of the components loose on the table.

The coil is made with aluminum wire wound on a black plastic coil with grooves. Everything is covered with heat shrink. Inside the form is a beautiful plate capacitor with air insulation.

The capacity of the capacitor outside the tube was C = 60.6 pF and in the tube C = 64 pF.

The bare inductance of the coil was L = 15.39 µH and with placed capacitor L = 8.10 µH.

The resonant frequency of the complete stage was fo = 7.05 MHz.

The caps that must keep the whole waterproof, will no longer suffice. Due to the penetration of moisture, the capacitor and aluminum wire sometimes oxidize properly, which in turn changes the resonance frequency. In order to improve things, the plan was to put the stairs in a gray PVC tube with lids. Because the self-assembly lockers met well, this did not happen and the FRITZEL traps were not (yet) used.

These two antennas are of German and American origin respectively. The last type is from B & W, model AS-40 for 10/15/20/40 m.

This is another German product with molded locking rings.

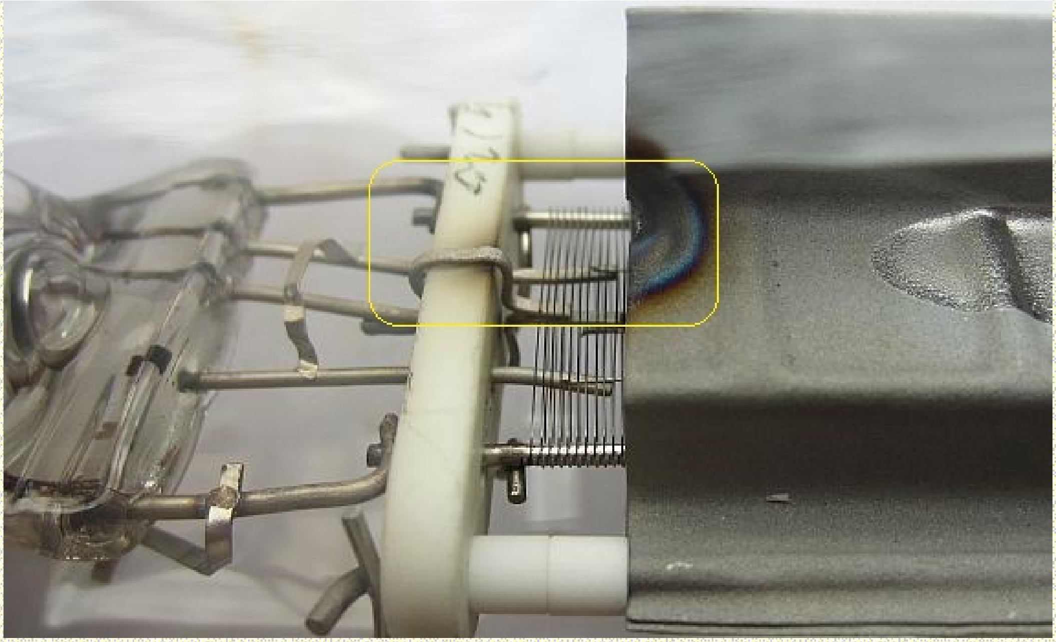
Ready made Traps

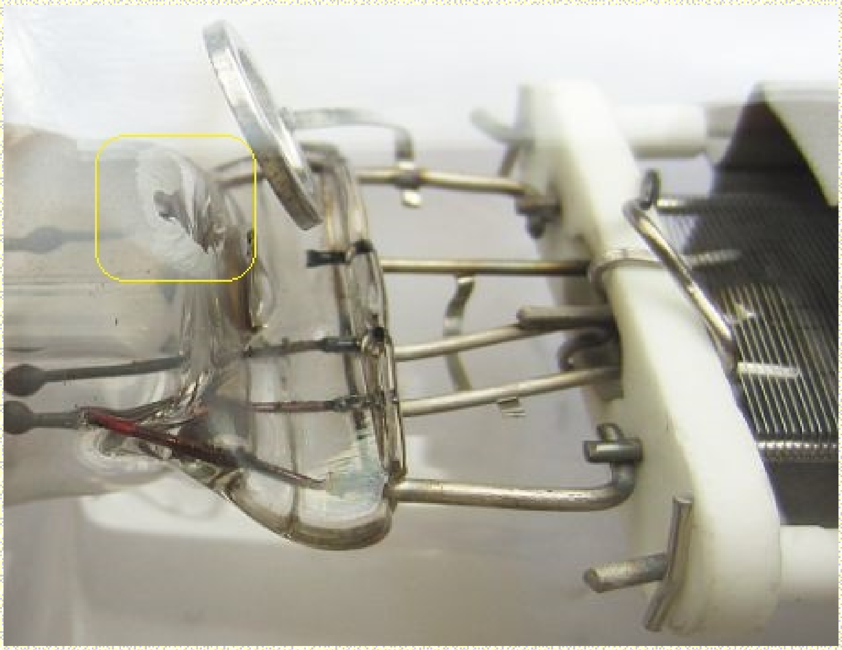
Ready-made lock rings are regularly offered in England, USA and Germany. Left: a German make, middle: type KW-40 are from Unidella from the USA, right: German traps made from cast 50 Ω RG58 coaxial cable. In the last construction, the wound cable is a coil and the cable capacity acts as a capacitor. Because the LC ratio is different than in the original W3DZZ design, the antenna will only resonate in the 40 and 80 m band and the dimensions of the dipole can deviate from the original W3DZZ.

AL-811H MODIFICATIONS

UPDATED 11- Dec-2015 Remove L7 and not L8.

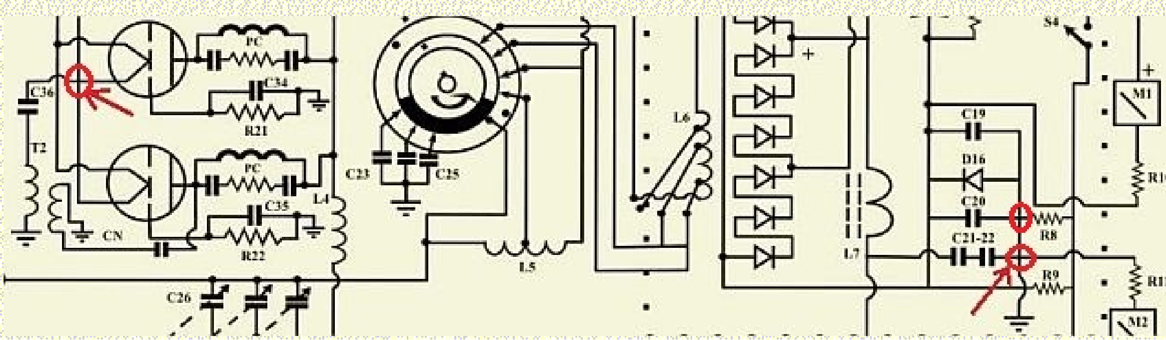
INTRODUCTION



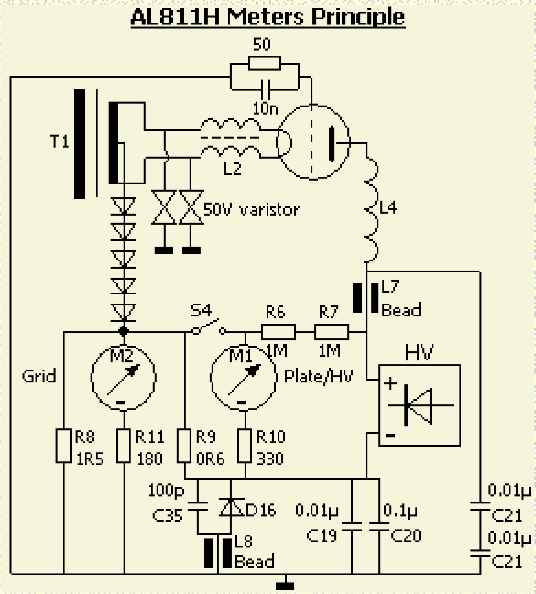


Flashover in a tube of an unprotected RF amplifier. The powerful spark induced scorching and inside a hole in the glass.

A fellow ham got an Ameritron HL-811H RF amplifier from estate of a deceased colleague. When he switched on the amplifier a flashover occurs and smoke swirled up. The PA had no additional protection and had not been operational for years. My inspection yielded a burned grid resistor and a partially conductive varistor on. The result was quiescent current in the standby mode and meters for anode and grid current showed respectively a positive and negative deflection.

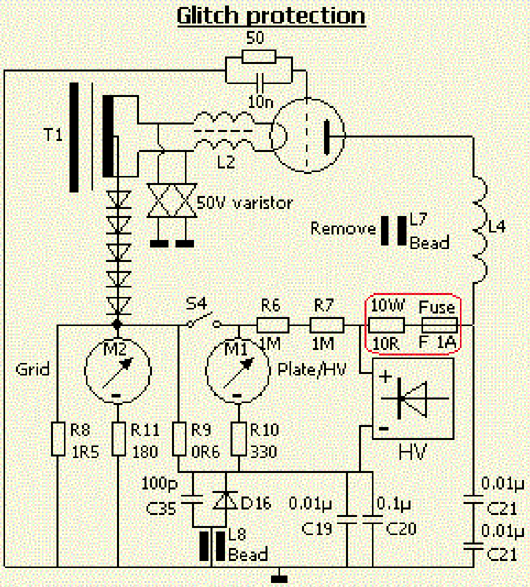


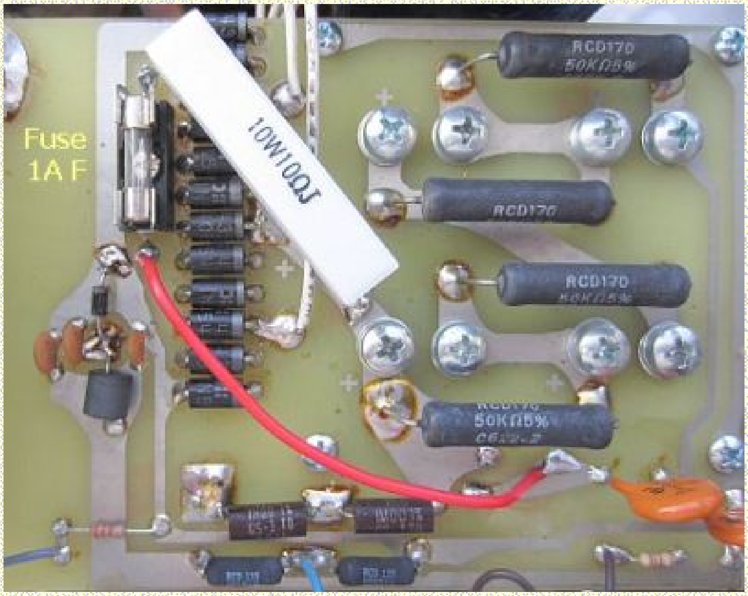
Irregularities in the schematic.



The AL-811H is sold worldwide and is quite a well-built "budget" amplifier, but by no means easy to repair. To dig in the amplifier almost everything has to be deinstalled. Getting to any component is a complete pain, one has to take the back panel off and release enough of the wiring on the large double sised PCB to get aught (e.g. varistor). Repair by a company will be dramatic considering man-hours involved. As radioamateur time is free and one can modify at random time. People of Ameritron are not keen in flawless drawing understandable diagrams. They are even inconsistent when drafting the components. Of the same device circulates different schematics! To more understand the track of the meters I drew the schematic differently. Now one can see how arcing in the tube blows the 50 Ohm resistor and partly conduct one of the varistors. D16 serves as protection of the meters and is also often destroyed by a flash-over.

ARCING PROTECTION





For decades, I advise to mount a resistor and fuse in series with the anode choke as flash over protection for tubes, rectifiers and transformers. It is a cheap, simple and proven effective method. Arcing is a momentary short (flashover) in one of the transmitter tubes.

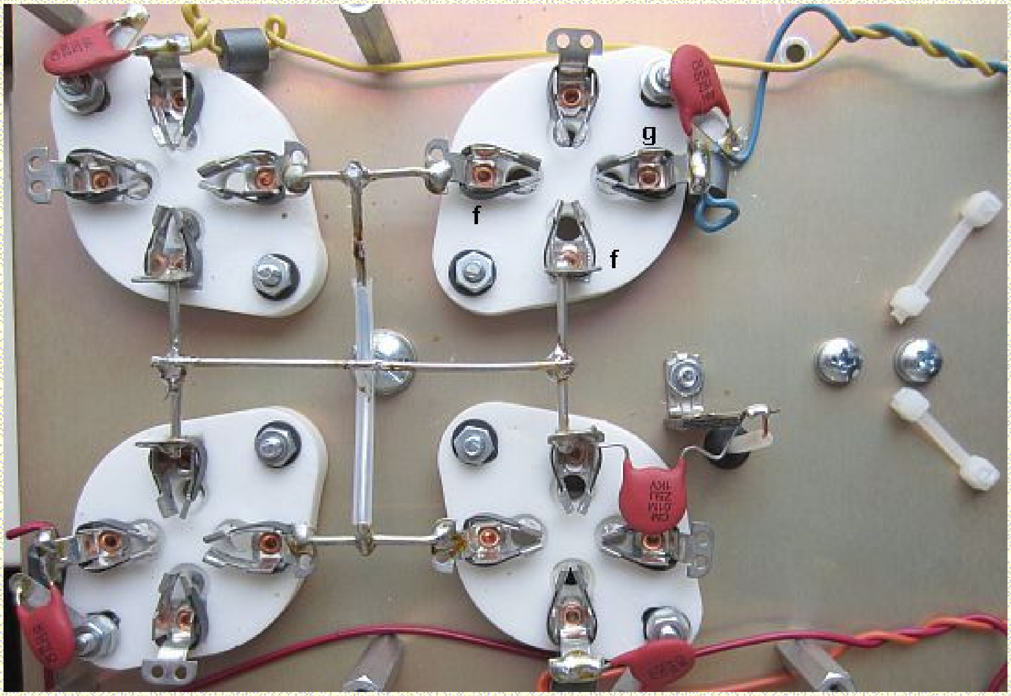
Before working on a amplifier with tubes, I always at first install (temporarily or permanently) the aforementioned protection. If anaything goes wrong, fuse blows, resistor limits the current and the latter also limit lenght of the arc in the fuse. Therefore, a small standard 230 Volt fuse can be used in place of a much longer HV fuse. The worst thing that happens is a fuse spattered apart and sometimes a intermittent resistance. That's nothing compared to a deceased tube, diodes, or worse a faulty transformer.

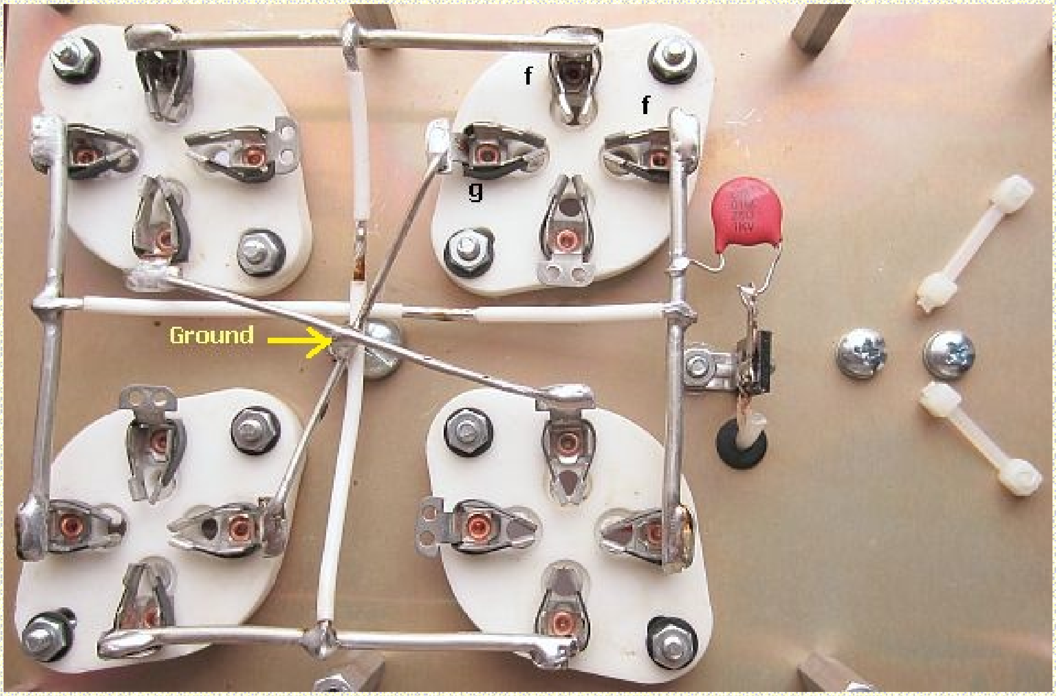
Mount a 10 Ohm/10 W wire-wound resistor, and remove ferrite bead L7 (RFC) at the bottom of the PCB. The wire-wound resistor also acts as a replacement for inductor L7.

If the PA is not used for a long time and goes back into operation, remove the fuse and let the amplifier an hour long stand idle. The filaments then have time to heat up the tubes so that they are sufficiently reactivated. My experience is that the mentioned time is sufficient for this type of tubes.

Incidentally arcing can also be caused by parasitic oscillation which is a result of misalignment of or inadequate grounding of components. Given its damage in the depicted tube, I think it's caused by parasitic oscillations, which led to a high voltage. The energy could not leave via the high impedance of the plate circuit, and so chose the shortest path via the tube.

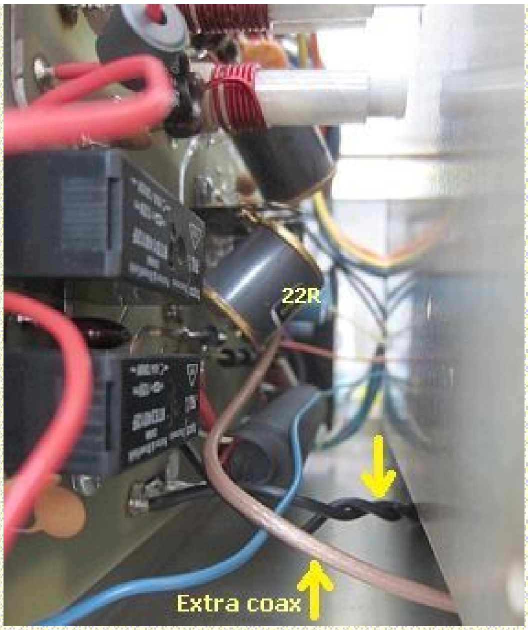
ONE POINT GROUNDING GRIDS

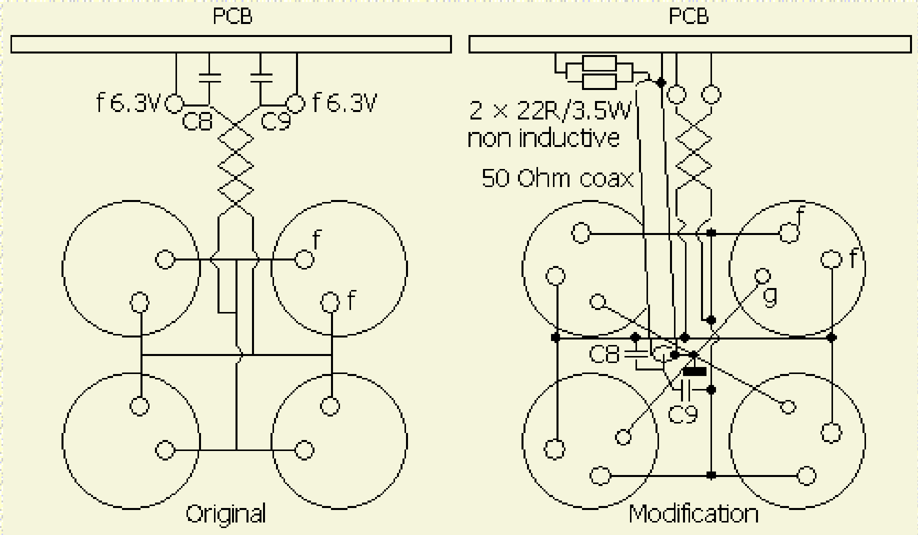




Left original wiring and right all grids directly grounded at one point, e.g. screw of the plate RFC.

Tube sockets rotated 180 °, grid capacitors, resistors and ferrite beads removed.



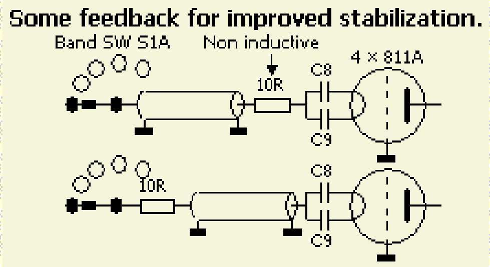


My belief and experience is that randomd oscillation of an amplifier with tubes usually can be reduces or prevented by using a single grounding point or reduce the lenght of a RF path considerably.

Designers too often assume RF current adequately travels through bolted or welded mechanical connections. In reality, no way to predict how the circuits actually behave. Therefore, in all my home made or modified amplifiers all grids are grounded via one point. That is even installed as modification in this AL-811H amplifier. I used as "earth" the screw at the bottom of the anode choke. The tube sockets were rotated by 180 ° in order to keep the distance of the grids pens to the ground point as short as possible.

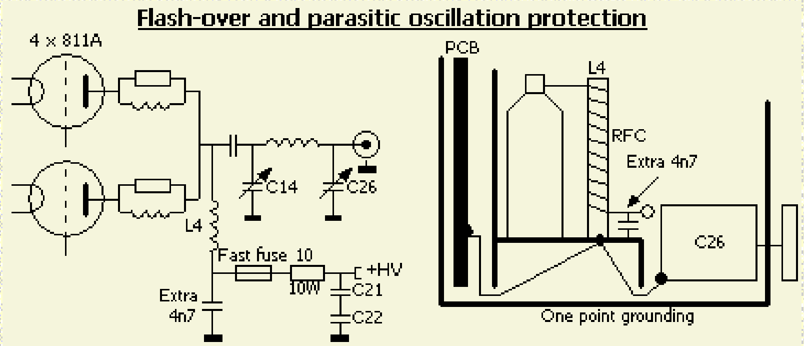
RF drive to the tubes is not directly onto filament pens, but from the PCB on the back through the wires of the filament supply. Further, the ground connection of the PCB with the ground of the grids is only connected by the longer path via the chassis parts. That seems an undesirable situation and therefore the drive is now done with an additional coaxial cable from the PCB to the filament pens. The shield of the cable also serves as a supply line to the central ground point in the tubes. I hope that the pictures are clear enough to understand the modicifications.

NEGATIVE FEEDBACK



Maximum drive of the amplifier is 75 Watt, but many of us have a 100 W transceiver. The least IMD is produced with that power. By applying an RF negative feedback, the set can be used as driver without any fuss. That's convenient and the feedback also prevents largely PA's overdrive and improves linear operation! The feedback system consists of two parallel-noninductive resistors of 22 Ohm/3.5 W between band switch S1A and cathodes (filaments). It will be clear that I had the resistors in stock. Because there sizes little space was to the valve sockets. Therefore they were mounted between band switch S1A and the coaxial cable to the cathodes. Optimal installation is between coax and C8, C9 but because of the short length of coax it proved to be successful. The more drive the more negative feedback.

EXTRA DECOUPLING CAPACITANCE



The plate RFC (L4) is decoupled with C21 and C22. Not close to L4 but far away on the PSU board. Was it a decision of the designer, an American ham, or an decision of the production department? I believe it's asking for trouble, and it is better to shorten the RF path by installing an additional 4n7 capacitor at the lower end of L4. Further, the bottom screw of plate capacitor (C26) is attached with a short wire to L4's screw, so that tuning capacitor has a shorter path to the central ground point and not via a long detour.

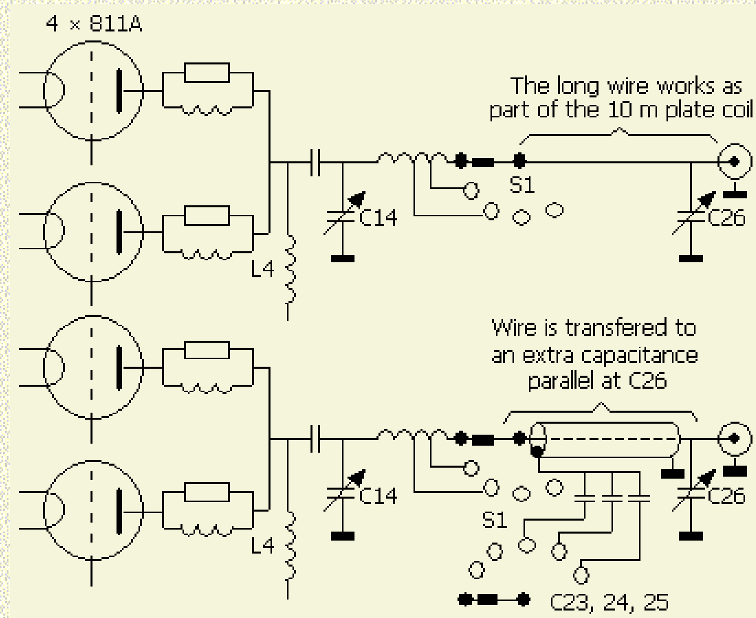
All previously shown modifications have improved amplifier's stability. One can test any PA with tubes by loading it with a dummy load and let it idle without drive. Turn per band load and plate control clock and anti clockwise and watch if there is any anode or grid current. If there is not, one can expect that the PA is quite stable.

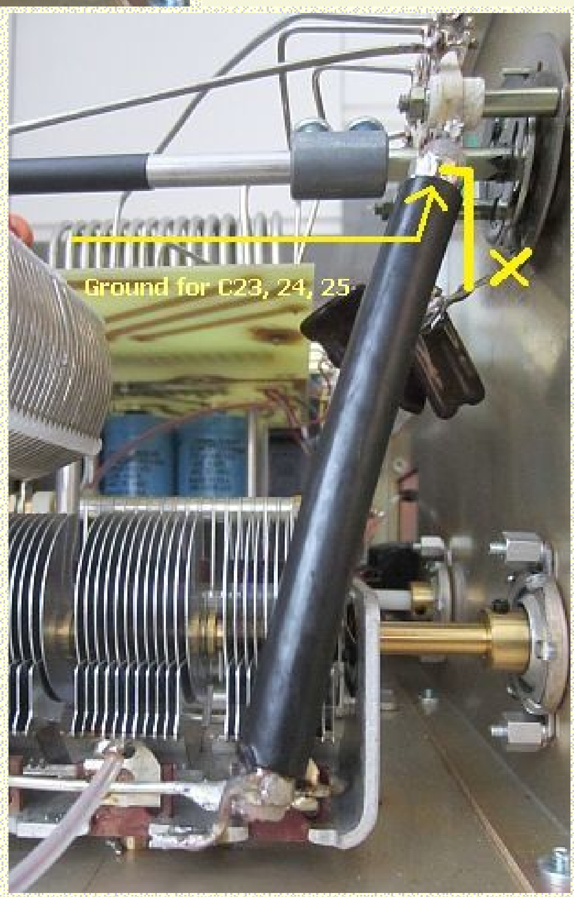
Due to the modifications the positions of Load and Plate will be different than you used to.

NEUTRALIZATION

The stability of the amplifier is increased by the principle of "single point ground", even with with three tubes of the same brand and one tube of another manufacturer. Therefore, nothing of the original neutralization system is changed. Often, neutralization is not necessary with a "single point ground" system.

TO LONG WIRE ON 10m



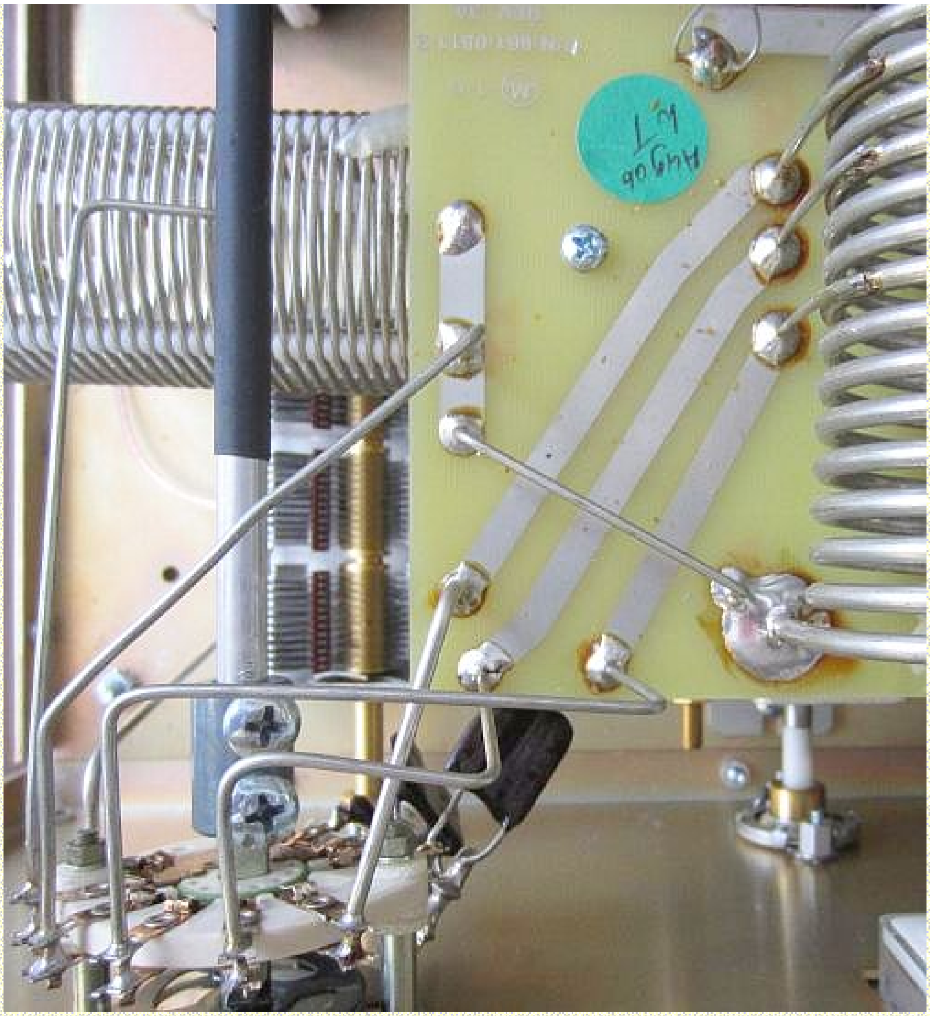


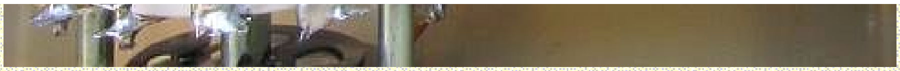
The long wire to be replaced by coaxial cable (RG213), so that the length is converted into a small capacitance in parallel with the load capacitor.

The size of the 10 m coil has become too small due to mounting method. The inductance of the long supply wires can not be ignored. In fact, it's more of a wire with too much inductance then a coil. It can be improved by replace wire from load capacitor (C26) to band switch (S1) by an equally long coaxial cable. The shielding of the cable is only grounded at the side of C26. With this method, the distance between S1 and C26 changed to a small capacitance in parallel with the load capacitor and the total inductance of the coil 10 m is thereby reduced. Without this change no equal output could be obtained at 24.9, 28 and 29 MHz.

The shield on the side of the switch is also used to ground C23, 24, 25 in order to decrease the "lenght" to the C26.

it would also have been better if the anode coil was mounted 90° anti clockwise reducing the distance to the band switch. Optimal is a separate 10 and 15 m coil.





At the same time the 10 and 15 m coil connections to the band switch were replaced by a thicker (6 mm²) wire for shorter installation. The exercises at 10 m increased the ouput almost 100 W.

The lean connection between plates and coupling capacitors (C13, C31) was improved by installing a wider flexible conductor under the motto: if it not improves it does not harm.

INPUT CIRCUIT

The input circuitry can adjusted on a favorite 20/30 m and 15/17 m band, for example a low SWR on 15 and 20 m. On the other band, the SWR will be high and is an (internal) tuner required for full ouput. If previous owners have been maladjusted the cores then turns anti clockwise so that they touch the back of the PA.

Connect the amplifier to a dummy load and adjust for maximum ouput. Tune not for a dip in the anode current. With four parallel tubes the dip is almost unrecognizable and it is almost never in line with maximum output. Turn the core clockwise until you reach a low SWR. Test and adjust the SWR also on the other bands. After adjusting this modified amplifier SWR on six bands was < 1.5.

REPLACE 811A WITH 572B?

Test AL-811H with tubes

4 × 811A				
m	Drive	Output	Ig	Ia
160	100	550W	200	680mA
80	80	600W	145	750mA
40	100	700W	150	750mA
20	100	650W	170	750mA
15	90	650W	165	750mA
10	100	500W	155	750mA

3 × 572B				
m	Drive	Output	Ig	Ia
160	100	550W	140	640mA
80	90	550W	150	640mA
40	100	600W	150	620mA
20	100	550W	135	640mA
15	100	550W	140	620mA
10	100	400W	100	600mA

There are regular discussions on forums about whether the 811A tubes can be better replaced by the more robust type 572B. My preference would be given to the latter because I have more experience with it. Therefore, a sumiere test was done with the two types. The numbers are not entirely fair because SWR to 572B's was worser than to original tubes.

After each modification the amplifier was firmly tested and plates never becames red. My conclusion is it makes no sense to install expensive 572B's if one not simultaneously increase anode voltage. More power does not seem sensible when considering that HV transformer is used in both AL-811A with 3 × 811A and AL-811H with 4 × 811A!

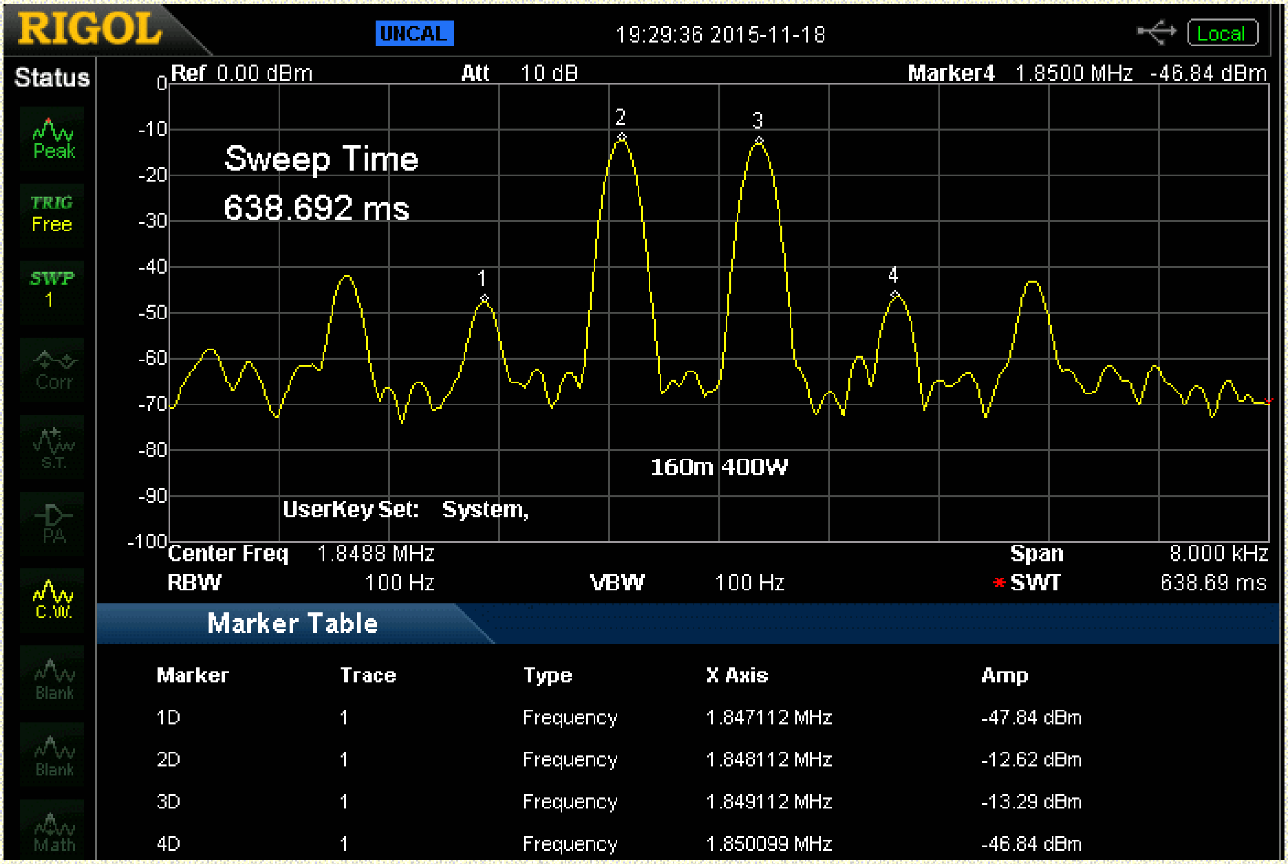
FINALLY

Dummyload Bird; Wattmeter Bird, insert 2500H

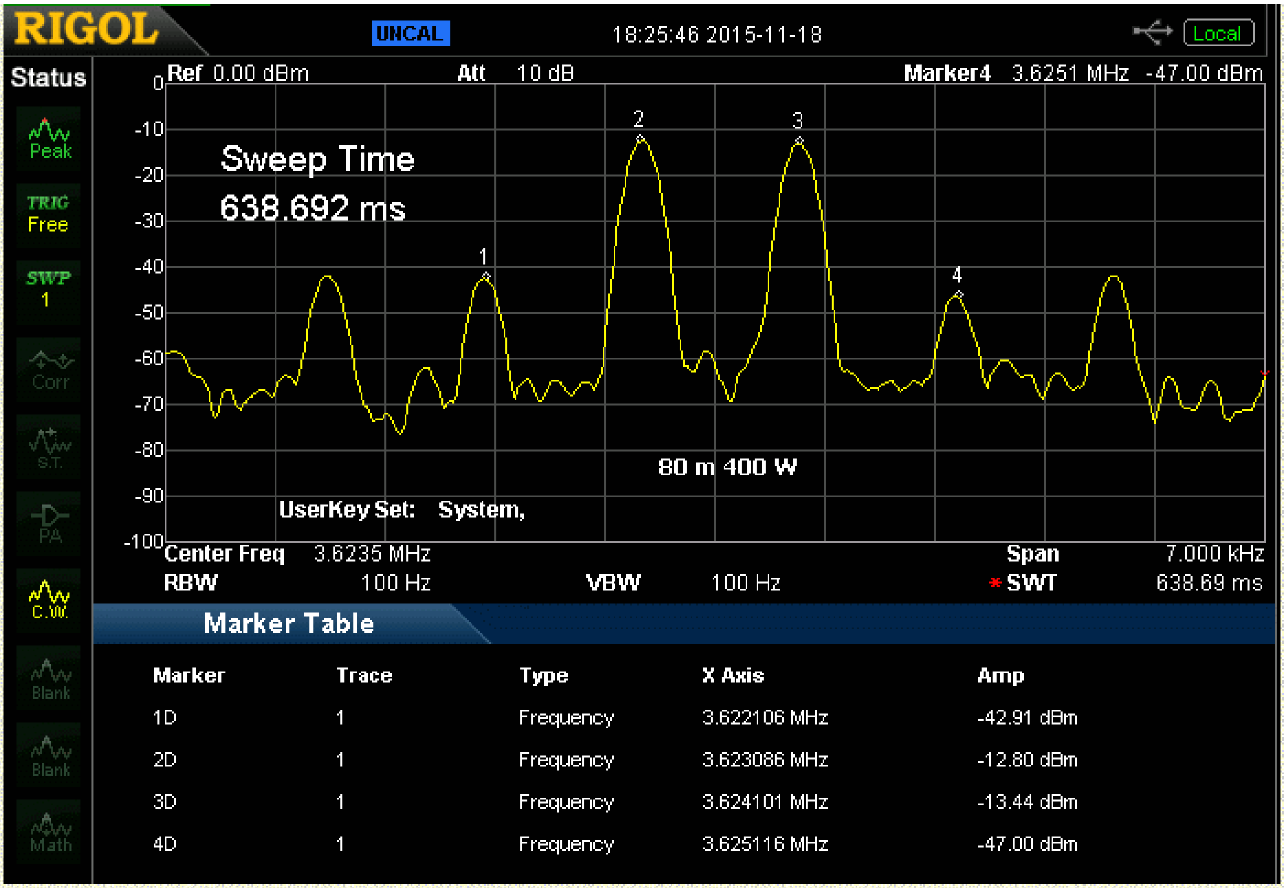
	160	80	40	20	15	10	m
Drive	100	100	100	100	100	100	W
Output	750	800	800	750	750	600	W

After mounting all modifications the power was measured with a Bird watt meter, 2500H (2.5 kW element, insert, slug, turret) and Bird dummy load. Drive power was

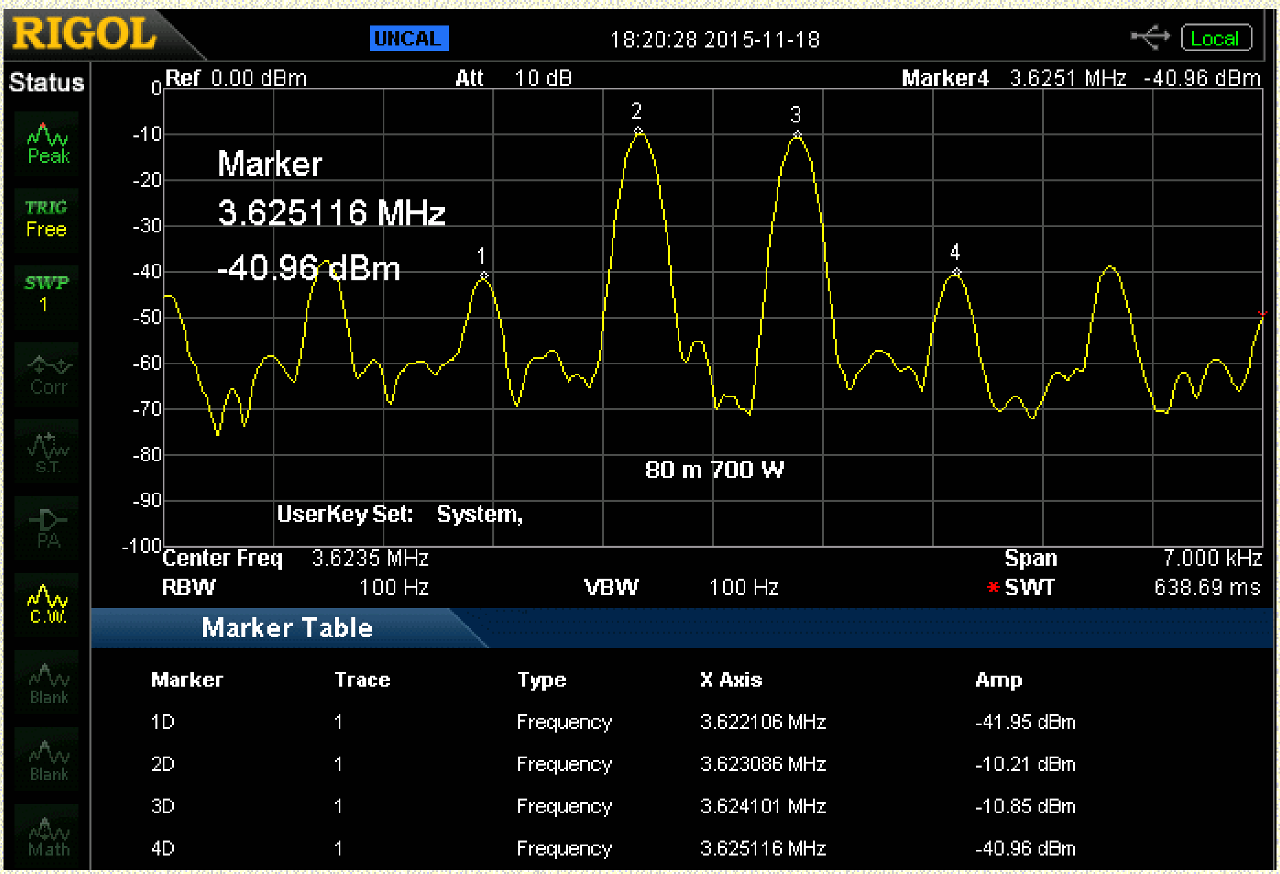
always kept at 100 W. Please note that the output in the table is partly achieved by exceeding the maximum grid and anode current. With SSB and negative feedback modification one could keep the measured transmit power safely because the average value is lower than with a carrier.



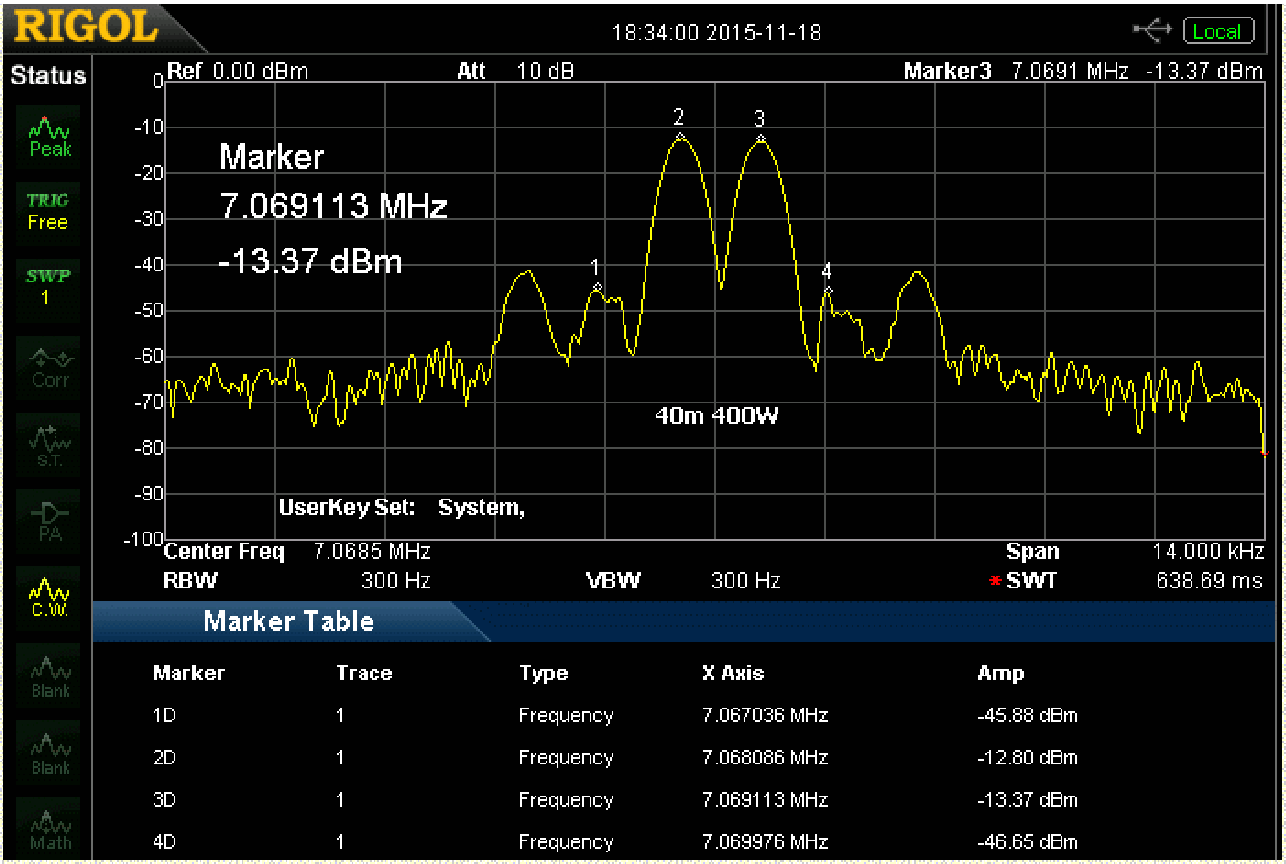
Third order -33.55 dBm



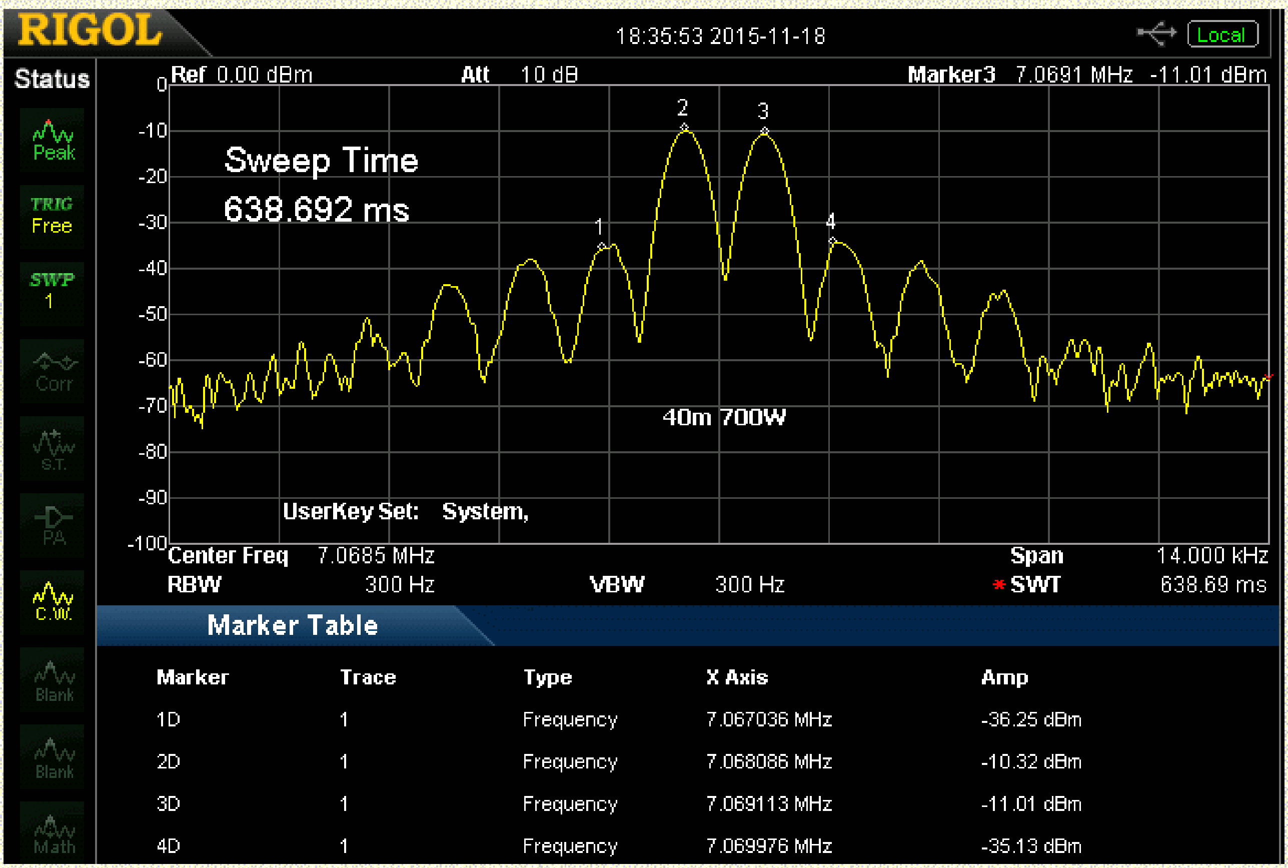
Third order -33.56 dBm



Third order -30.11 dBm



Third order -33.28 dBm



Third order -24.12 dBm

Some images of a spectrum analyzer in order to get an impression of IMD behavior of this amplifier. The suppression of the third-order harmonic is the difference between marker 3D and 4D. It should also be mentioned that the SDR driver stage showed almost the same IMD image. A tentative conclusion is that this AL-811H does not distort the signal of the drive stage.

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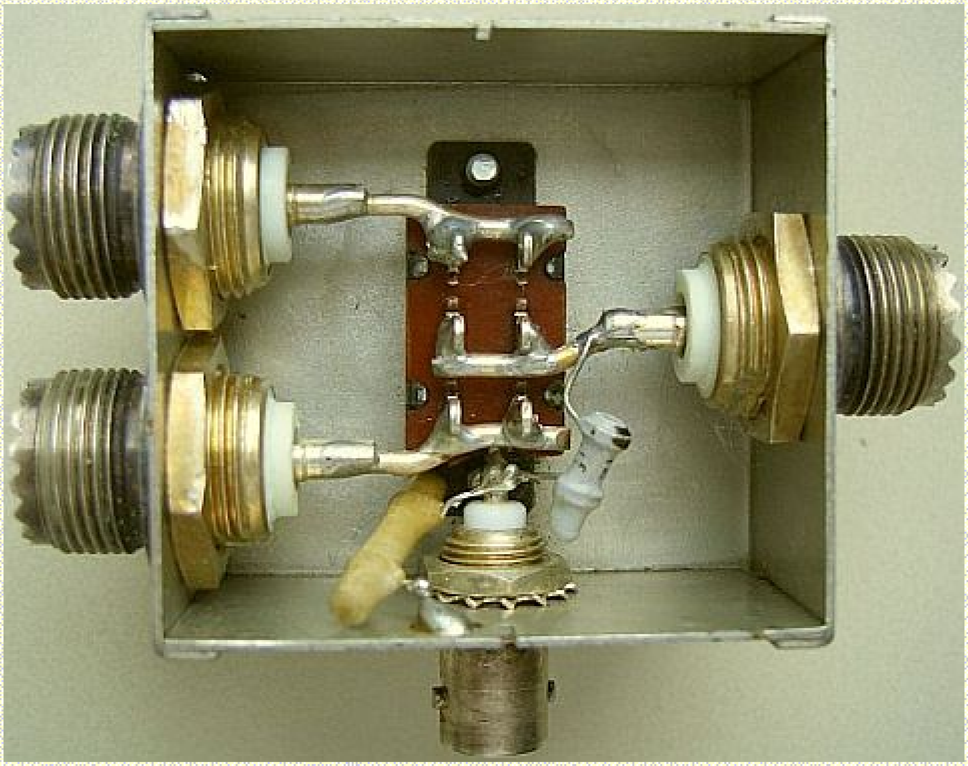
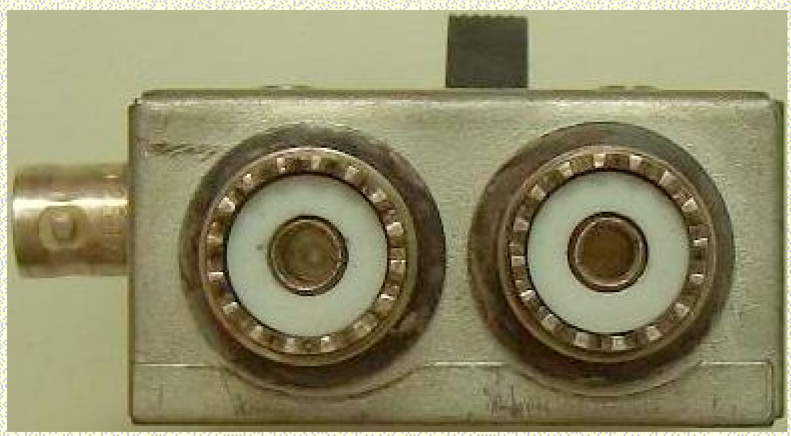
A Coax Switch



Cheap slide switch in a standard 54 × 50 × 26 mm box.

THE SWITCH

Fig » shows a proven inexpensive home-made antenna selection switch. If you question the use of a cheap slide switch and SO239 coax sockets, read on. Measurements in a physics lab showed there to be practically no reflection on HF and even on 70 cm the SWR was below 1.3 : 1! That is explained as follows:

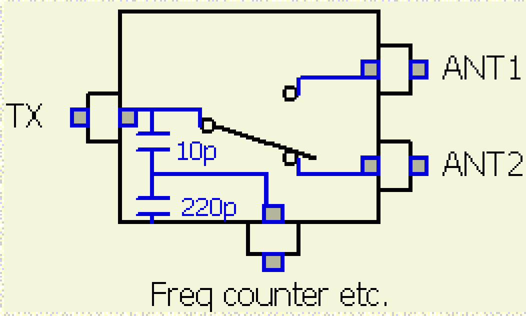


- The contacts in the slide switch have larger contact surfaces than many a bought coaxial switch.
- The wiring and switch contacts, between the top and bottom of the metal case, act as the centre conductor of a coax of near 50 ?.

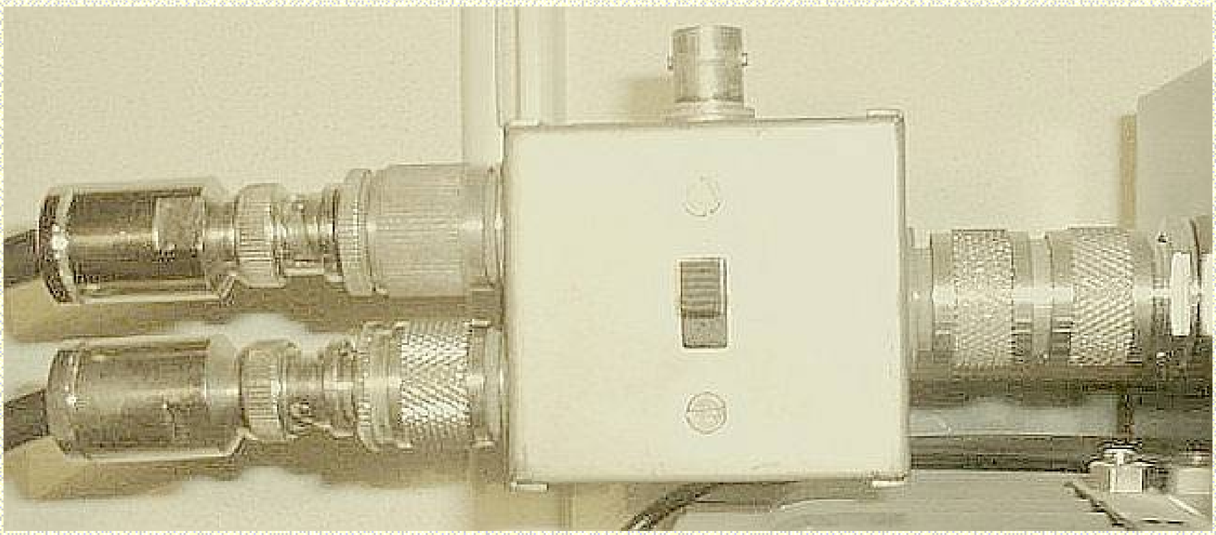
It is a standard box measuring 54 × 50 × 26 mm (l × w × h) and the wiring between the switch and the coax sockets is done in 2 mm silver plated wire.

POWER HANDLING CAPABILITY

If the switching is done with power off, the switch can stand 800 W. I have used this switch for more than 15 years and even with 1500 W there have been no problems.



While building this switch, you might as well add a test point, e.g. to connect a 'scope' or frequency counter. The capacitors of 10 and 220 pF make a capacitive voltage divider and the extra loading, 9.6 pF, does not affect performance on HF. In fact, on 10 m it improves the SWR as the extra capacity, in combination with the wiring it makes a filter which favours that frequency.



This shows how the switch is used in my station.

BIRD 43 ACCURACY SUSCEPTIBLE TO TEMPERATURE

Bram Bottema, SM0FLY, April 2012

PURPOSE

This paper describes Bird 43 Wattmeter's power reading in dependency of temperature. Absolute accuracy is measured as a second parameter as well as the accuracy and reproducibility of the measuring method.

MATERIAL

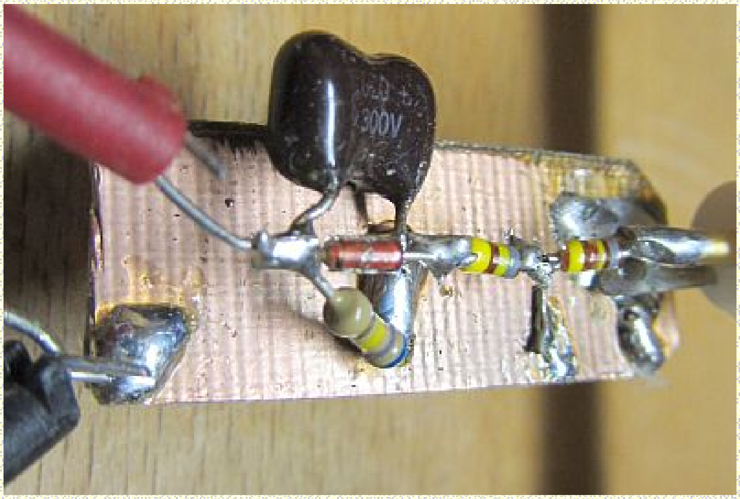
1. Bird 43 serial# 42870
2. Slug Coaxial Dynamics type 82006: 2-30MHz 250W
3. Dummy load 50? Philco 160B-150FN serial# 1138
4. HF to DC peak detector , lab made

5. DC voltmeter APPA 65 & DVM part of THS730A
6. Variable RF power generator 2-14MHz 10-100W (IC751A)
7. Resistance measurement with TTi LCR400 and APPA65

Accuracy of the above (3) to (6):

- Dummy load (3) was measured to be 50.0 ohm with the TTi LCR400 and APPA 65 which was checked/ calibrated against a certified standard of +/- 0.5%
- The labs made peak voltmeter (4) characteristics were measured and are discussed below.
- The DC voltmeter APPA 65 (5) was checked against a traceable standard.
- The power RF generator IC751A (6) was measured as having 2^{nd} order harmonics of < -55dBc and 3-7thd order < -60 to -80dBc

The HF to DC peak voltmeter consists of 3 x 1N4148 diodes in series and terminated with (fig») a 680 pF mica cap. and a parallel resistor of 680 k?. It was checked that no significant output voltage ripple occurred at the chosen measuring frequency.

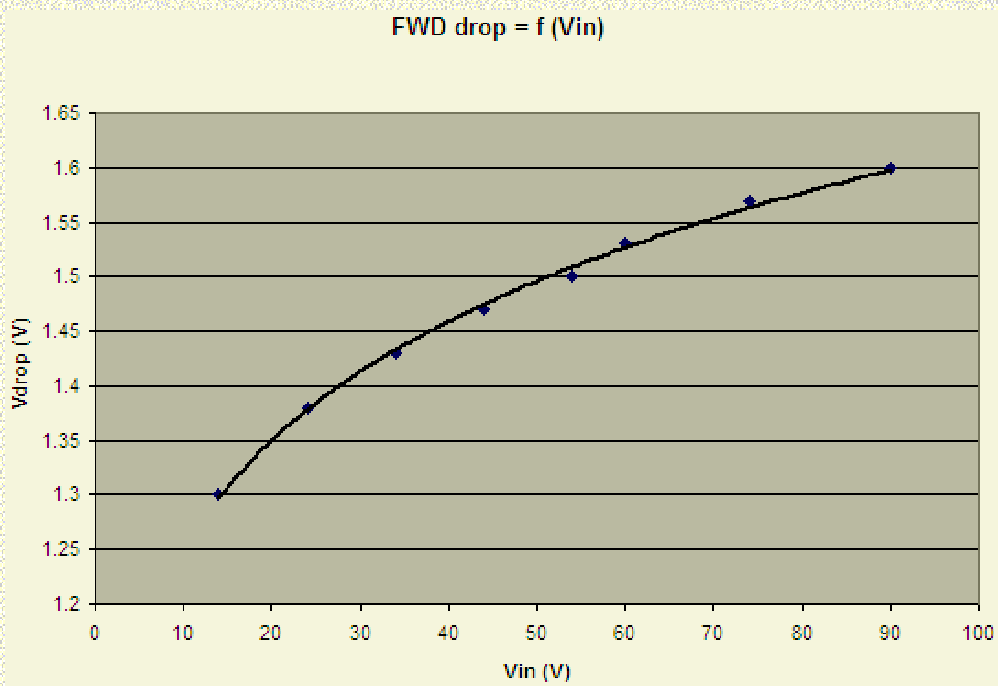


TEST METHOD

The Bird 43 analogue built-in meter is stated to have a range of 30 µA. A variable PS of 0-30 V was used in series with a resistor of 1 M? to verify the stated range. This full-scale mark was measured to be 28.5 µA, i.e. a deviation of 5%.

The temperature dependency in the range 12-25 °C of the meter without slug was measured to be negligible.

Set-up.

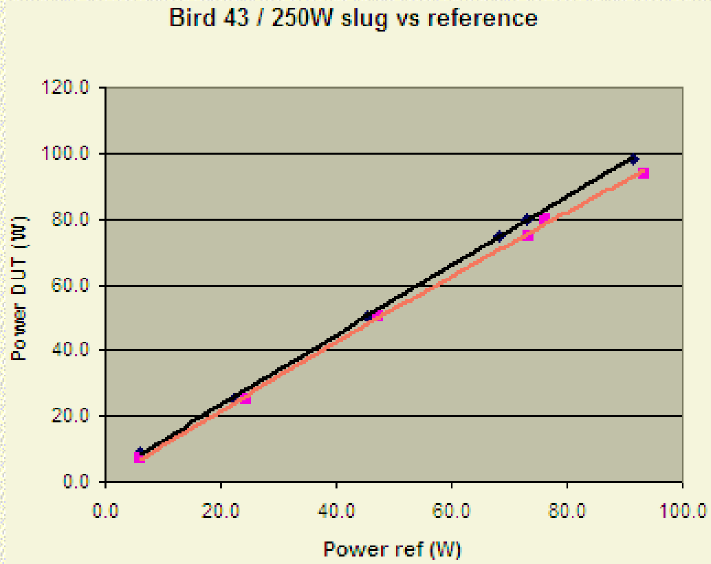


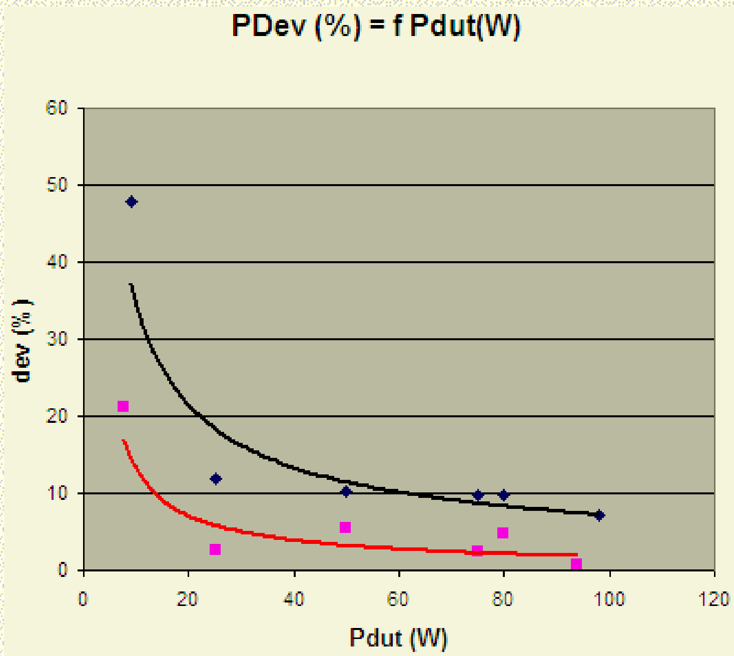
A T-connector is used to tap the RF signal to the peak detector. This set-up shows negligible frequency dependency between 2-21MHz. The test frequency was set at 3550 KHz, which is well within a span where secondary parasitic effects are negligible.

The peak detector is used to measure the absolute power including the voltage loss over the 3 × 1N4148 diodes. Therefore the voltage loss was determined using DC current within the same range as the measuring set-up. The diode voltage drop over the measuring range in the peak detector is plotted in the right figure below.

The laboratory temperature during the tests was between 22.0 - 22.5°C. The slug temperature was varied between 15°C and room temperature.

Taking the diode voltage drop in account, the measured peak voltage is recalculated to a RMS voltage and towards power into the dummy load.





The left figure shows the measured vs. Bird 43 power reading at 22°C (black) and 15°C (red) and the right figure the error in % of the reading.

A less reproducible test was done by cooling the slug to -15°C. In this test it was not possible test to have a stable temperature in this range. It was clearly seen that the power reading was approx. 20 W lower compared to room temperature, increasing the error at mid scale to > 20%.

CONCLUSIONS/SUMMARY

The Bird 43 wattmeter is a rugged portable wattmeter with a practical way of changing frequency and power ranges. The slug is an analogue device where certain temperature dependency takes place for what is not compensated. For maximum reproducibility the Bird 43 must be handled within a very limited temperature environment.

FOOTNOTES

The peak voltage test was chosen as accurate attenuation still have tolerances of +/- 0.1dB which equals to a power range of ~5%. A peak voltage test transferred to power is only valid and calculable if the voltage is sinusoidal, therefore the source must have a high harmonic suppression. The frequency dependency of the peak detector is reasonable predictable by the internal capacitance's of the diodes and T-connector. Verifying this with a frequency sweep is a solid method.

The analogue scale of the Bird 43 is compensated for the diodes nonlinearlity in the slug(s) but, as this is temperature dependent, a non-compensating error will always exist in this analogue device.

REFERENCES: http://www.dxstore.com/download/Bird_43_Series_Manual.pdf

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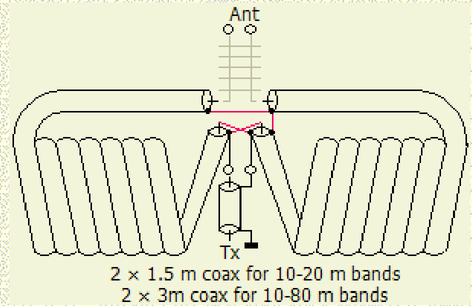
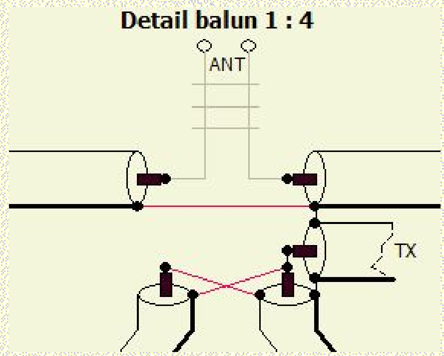
PA0FRI

COAX BALUN 1: 4 and 1: 1, CREATE AND APPLY

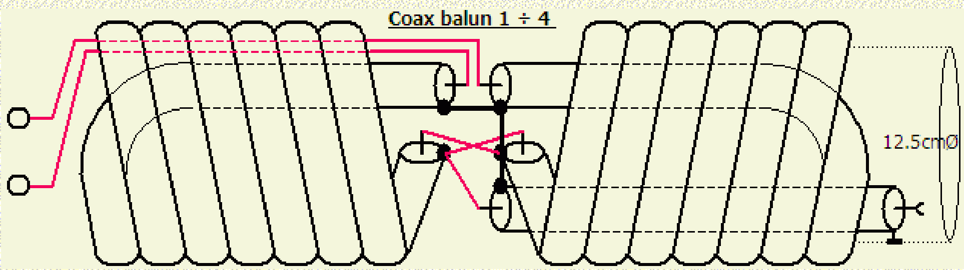
(EVENTUALLY 1 ÷ 6 and 1 ÷ 9)

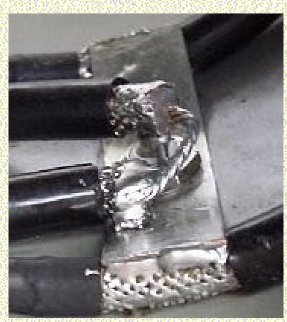
July 12, 2016

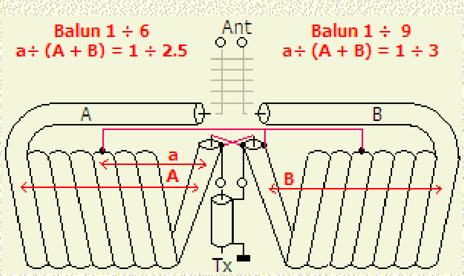




Indoor 1: 4 balun (33 μH)

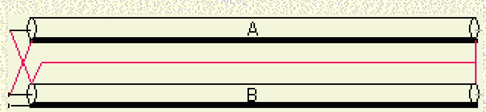






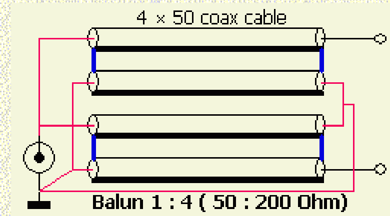
Turns ratio.

BALUN 1 ÷ 4



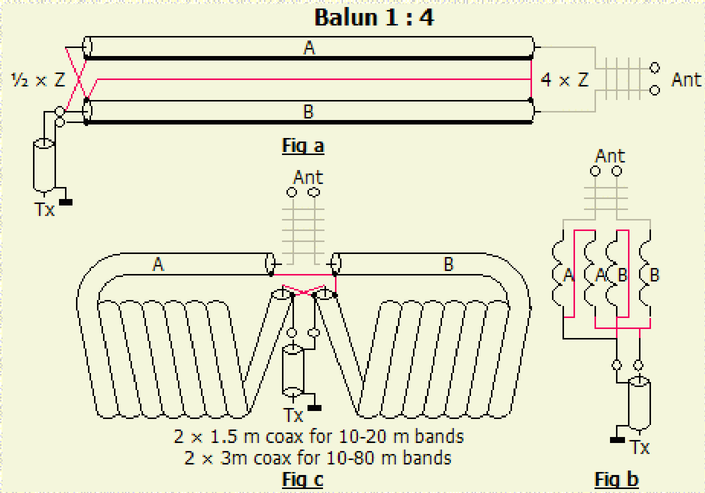
An air-wound balun made with coaxial cable can not become saturated because no powder iron or ferrite core is present.

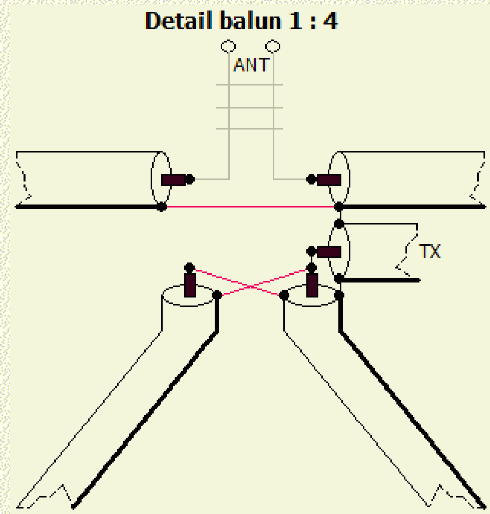
The system consists of two equal lengths of coaxial cable (fig ») which are connected in parallel on the one side and in series on the other . With 50 Ω or 75 Ω coaxial cable means that a transformation takes place of respectively 25 Ω: 100 Ω and 37.5 Ω: 150 Ω.



If you want to have an exact 50 Ω: 100 Ω ratio, two pieces of coaxial cable of 100 Ω are required. You can also take four equal lengths of 50 Ω and then switch two by two in parallel so that two pairs of 100 Ω (fig ») are created. Then the beginning of the pairs is the beginning parallel and the end is connected in series.

Incidentally, a transfer ratio 1 ÷ 4 will only go if a real ohmic impedance (no + j or -j) of the correct value is offered. Balancing for a deviant complex impedance remains good, but it is even possible that it is not up but down transformed. Therefore, this balun is only suitable for adjusting a balanced load such as an open line with an asymmetrical tuner.

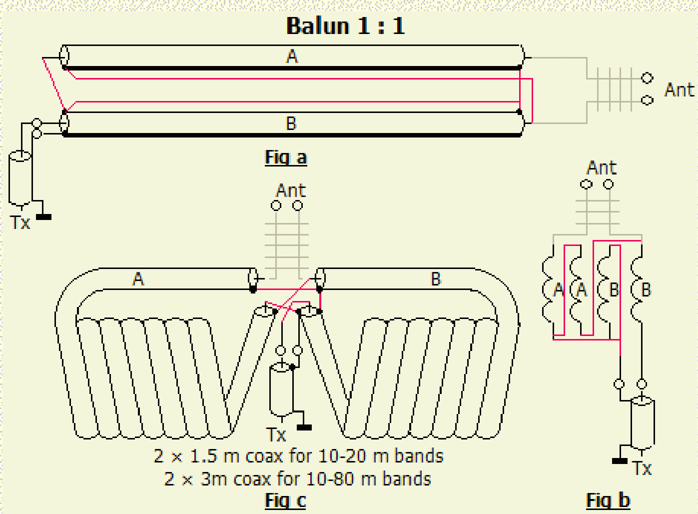


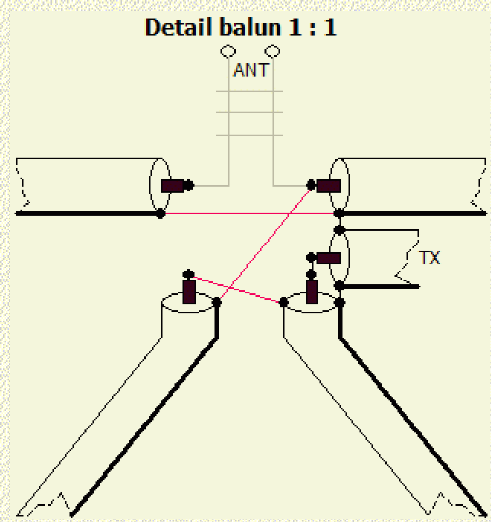


In this way, one obtains a balance transformer or balun with an almost perfectly balanced output is my experience. The principle is drawn (figure b) with two coupled coils consisting of 2 × A and 1 × B. The other B coil does not join because it is short-circuited.

In the first drawing, it can be seen that cable B does not have a phase and does not take place by cable A. To separate in and out of A sufficiently, a piece of ¼ wavelength would be required. By rolling up a shorter piece of cable, an insulating choke coil, also known as a mantle choke or choke balun, is created for the outer casing. Since the non-short-circuited coil B in and output are in phase , this does not have to be a coil, but can possibly be mounted separately. In order to keep the whole compact, cable B is also rolled up on the same coil shape. PAØSE has devoted various articles to the theory of this balun in ELECTRON and therefore the practical side and application will be highlighted here.

BALUN 1 ÷ 1

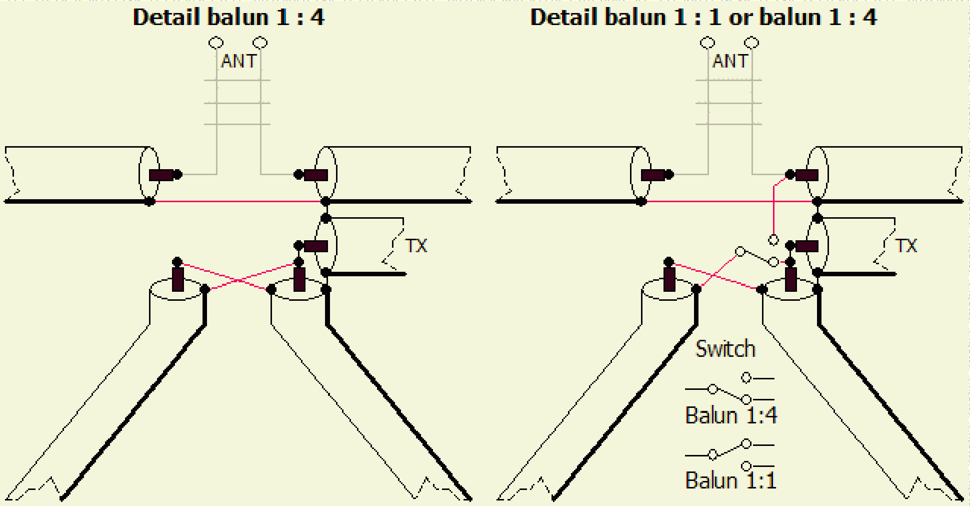




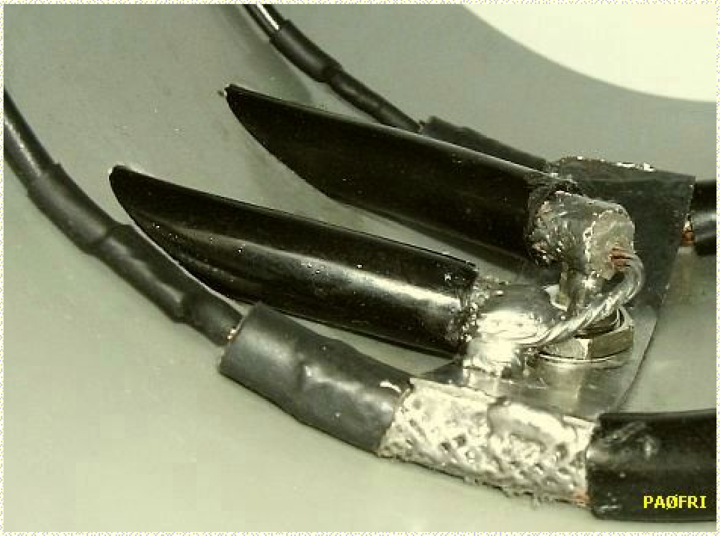
It is also possible to make a 1 ÷ 1 balun in such a way, see the above drawings.

TO CHOICE 1 ÷ 4 OR 1 ÷ 1

The following I have not yet encountered in a publication, because with a switch (fig ») it is possible to change from a ratio 1 ÷ 4 to 1 ÷ 1. It is quite common that the start of an open line is low impedance. A 1 ÷ 1 balun then gives a more favorable adjustment for the tuner, resulting in a better return.



CONSTRUCTION



My structure (for indoors see above) differs from the model published by PAØSE. This was the result of experimenting after reading an article in Technical Topics in RadCom from RSGB. It is striking that, independently of each other, both constructions have become the same. The cables (RG-213 / U) are unwoundly wound onto a 12.5 cm diameter shape and inserted in such a way that all ends come out as close together as possible. The latter greatly promotes symmetry and reduces the added self-induction of the interconnections. The points of low impedance lie together and from high impedance with long lead

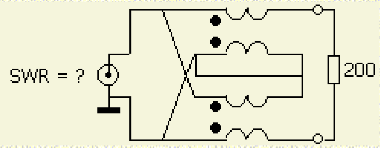
wires apart. With the disadvantage of longer connections, the coils can also be arranged on two separate tubes.

For the range of 10 t / m 20 m and 10 t / m 80 m, 2 × 1.5 m and 2 × 3 m respectively are sufficient. If you use 75 Ω cable, then the losses are less than with 50 Ω coaxial cable.

The larger model on a 16 cm diameter PVC pipe was made for a friend at a later stage. The small model has its own inductance of 33 μH parallel to the power supply line, which is approximately 60 μH for the larger model.

RG213: ± 60 μH = 2 × 8 windings, pipe 16 cm Ø and ± 33 μH = 2 × 7 windings, pipe 12.5 cm Ø ,.

SWR



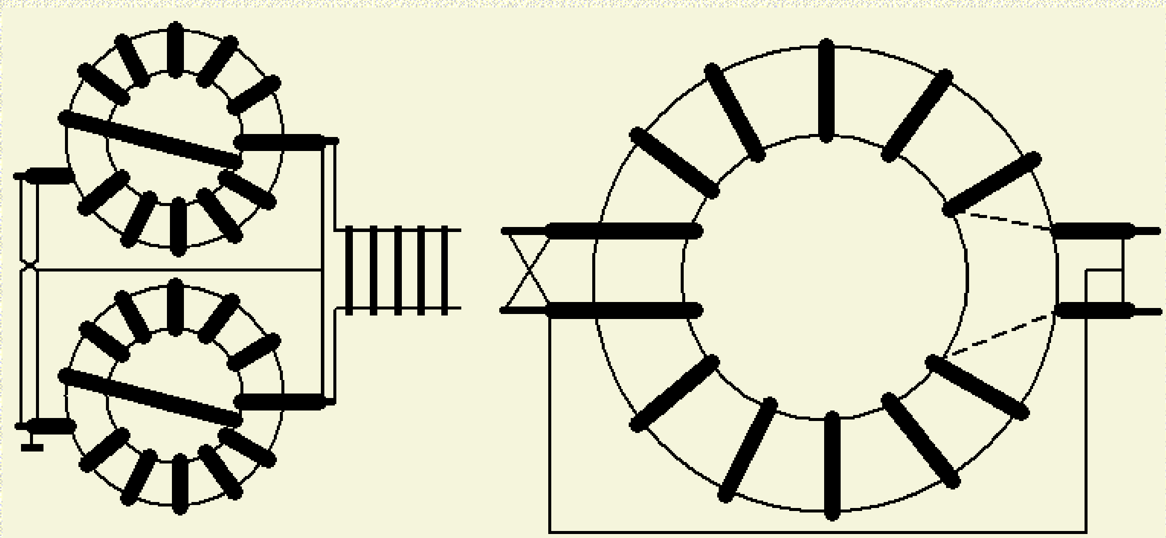
The SWR at the entrance of such a balun will generally have a low value if the output is terminated with an inductance-free resistance of 200 Ω. At the balun, despite the best possible construction, the SWR was relatively high when a 200 Ω resistor with 2.5 cm long connecting wires was attached to the output. The lowest was SWR = 1 at 2.5 MHz and the highest SWR = 5.6 at 15.08 MHz.

RG213									
Band	**160**	**80**	**40**	**30**	**20**	**17**	**15**	**12**	**10**
SWR	**1.4**	**1.4**	**3**	**4.3**	**5**	**5.1**	**3.8**	**2.2**	**1.1**

The "strange" outcomes are the result of a balun that has no impedance of 50 Ω ÷ 200 Ω but of 25 Ω ÷ 100 Ω because instead of 100 Ω is 50 Ω (RG213) coaxial cable used! It will be clear that it is not an ideal balun for a broad-band adjustment of a real 50 Ω to a reflection-free 200 Ω load. As a link between the ATU and the supply line this is not an impediment and only the most important characteristic is used: the almost perfect symmetrical transfer of a symmetrical signal. There are "experts" who let go of a network analyzer on such a balun, can not interpret the outcome of the test and then show that the system is not good. Have they actually tried using an antenna system in a laboratory?

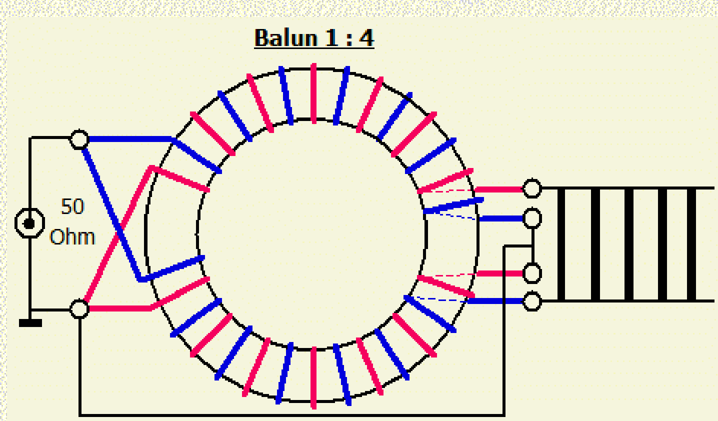
Examples of some homemade 1: 1 baluns. The right can be switched for 1 ÷ 4 or 1 ÷ 1.

CONSTRUCTION WITH RING NUCLEARS

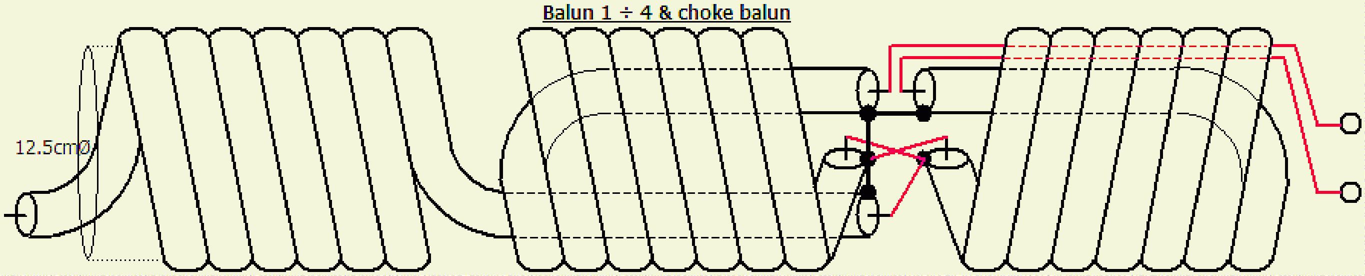


The size of the balun can be greatly reduced with suitable ring cores, for example type 4C6 and 4C65. Try to place as many windings from, for example, (PTFE) RG58 coaxial cable on the cores and connect the ends according to the drawing. The ability that this combination can handle depends strongly on the size of the ring core and the core material.

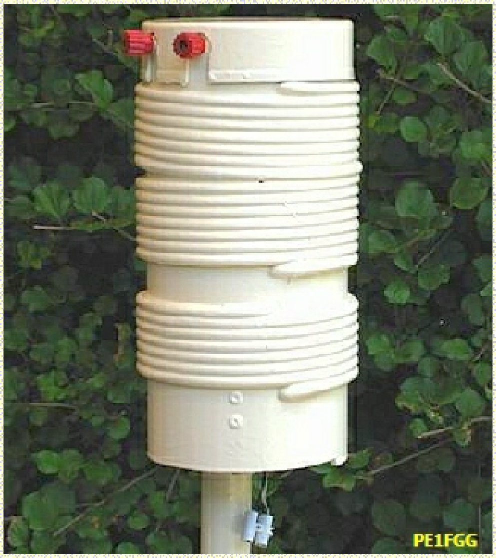
If only one core is used, the second coaxial cable or the second pair of windings must be arranged opposite the core, as is best illustrated on the drawings. In fact the same system as the opposite coils of coax cables on one plastic pipe.



BALUN & CHOKE BALUN



Choke balun and 1 ÷ 4 balun joined together.



An even better insulating effect is achieved by adding a casing flow filter (choke balun). Use about 3 meters extra coaxial cable for this purpose by winding it under the balun as a coil. In fact, that is the last part of the coax cable between ATU and balun. PE1FGG followed that advice and also mounted a relay in the coil form to be able to choose from a 1 ÷ 4 or a 1 ÷ 1 transfer ratio. At the top right you see the switchable balun during a test period and on the right the white "artistic" end product. His findings:

YAESU FT-897.

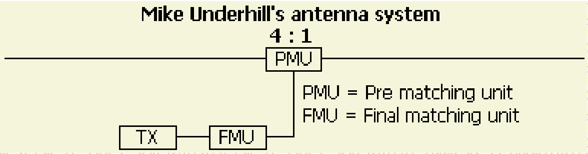
Output 30-60 W PSK.

Antenna G5RV JUNIOR.

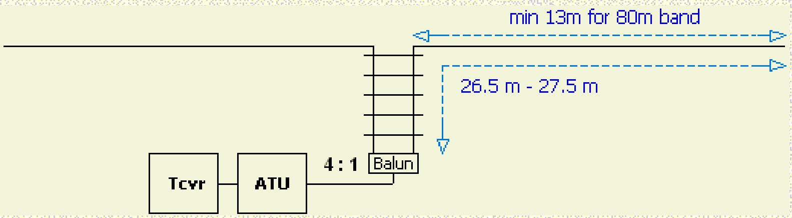
With 1 ÷ 4 switched on, the internal tuner FC-30 (SWR 1: 3 max. 16.5 - 150?) Can be adjusted at 40/30/20/17/12/10 m. An external ATU is only needed on the 15 m belt.

APPLICATION

Prof. dr. Mike Underhill, G3LHZ devised the system to coordinate a dipole ("fig") over a broad spectrum via a coaxial cable and a 1 ÷ 4 balun in the feeding point. A suitable tuner for HF bands can then consist in its simplest form of one coil coil and one capacitor. The SWR in the coaxial cable is lower in design than a system where the power supply line



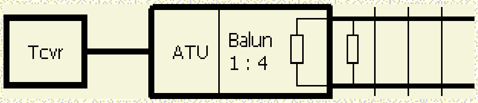
is directly connected to the power supply point. G3LHZ calls the balun to bring down the SWR in a first step, a pre-match unit (PMU) and the tunable ATU a final match unit (FMU)



My idea was that losses are even less when the balun is not at the feeding point but at the beginning of an open line (fig »). The supply line should be as long as possible for the location. Extensive tests have shown that the most loss occurs in the connection between tuner and balun. If the balun is switched almost immediately with a piece of coaxial cable behind the asymmetric tuner, then the antenna current is the same as if the system was adjusted with a symmetrical tuner. Then in many antenna systems it does not matter which adjustment is chosen, but with the extension of the coax cable the losses of asymmetrical system increase. See also the application in the article Antenne Potpourri .

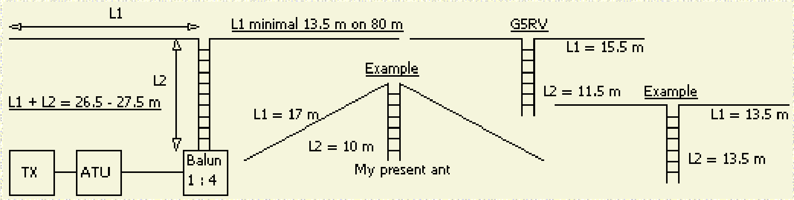
IMPEDANCE BALUN

An important aspect that is often underexposed is the self-induction of the balun coils . For a good transfer of HF energy, the inductance of the secondary coil (in?) Must be four to five times as large as the adjustable impedance. My balun had a self-induction of 32 μH on the open line side. That is at 3. 5 MHz, Z = 2ΠfL = 2 X Π X 3.5 X 32 = 704? (Π = pi).

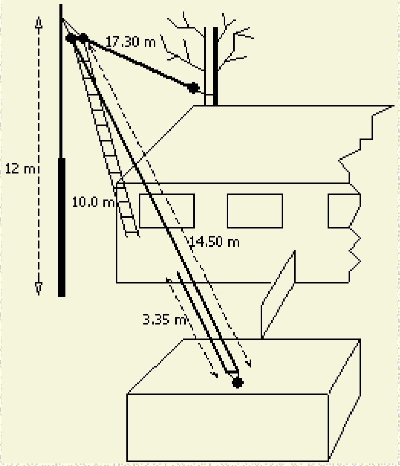


Because the antenna is not in resonance, an open line counts as a transformer. Suppose that there is an impedance of 600 at the beginning of the power supply line at 80 m. There is then ("fig) 700? from the balun to parallel. It will be clear that about half of the transmission power in the form of heat disappears in the balun. At 40 m the value is 1400?, At 20 m 2800? etc. The higher the frequency, the better it gets. In this example where the impedance at the beginning of the open line was set at 600 ?, does an effective transfer at 80 m only take place if the "resistance" of the balun coil parallel to the start of the open line 600 × 5 = 3000? is. That is a self-induction of 136 μH.

LENGTH DIPOOL



My experience with this balun is that the length of a half dipole plus the length of the feed line should be about 27 m (26.5 -27.5 m) for 10 to 80 m. With this dimension the balun is not too low or too low. high impedance offered. With the known G5RV, the feed line would then have to be about 11.5 m.

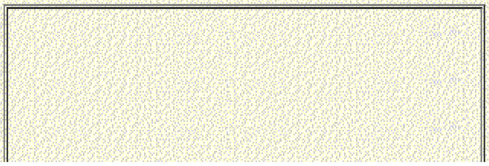


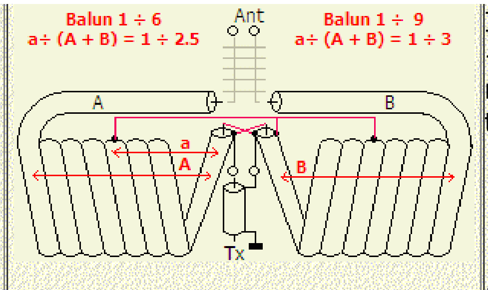
The losses in the whole system are low because a tuner does not have to do that much. Often an internal tuner of a modern set can adjust the system to a SWR = 1. A simple asymmetrical ATU is also sufficient and with my then antenna it was possible to work on 8 bands with a FRI-match antenna tuner. That was at a dipole of 2 × 13.5 m with a feed line of 13.5 m.

In order to be able to work at 160 m with as few losses as possible, the proposed size of 27 m should be approximately 54 m (= L1 + L2).

With my current inverted V antenna (fig »), the built-in tuner of a TS-450 and the external automatic tuner of a TS-50 were able to adjust the antenna on all bands from 10 to 80 m.

BALUN 1 ÷ 6, 1 ÷ 9



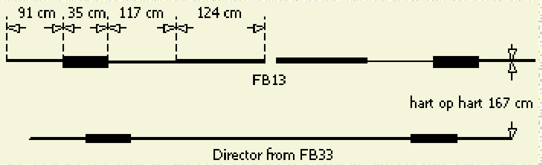


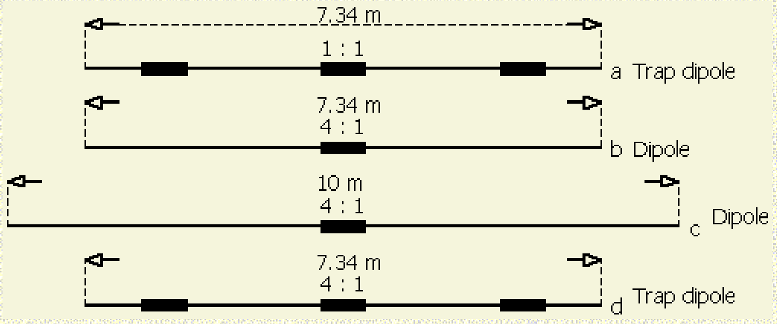
Turns ratio.

I was asked whether it is also possible to make a transfer ratio of for example 1 ÷ 6 or 1 ÷ 9. That is well possible, although I have not yet done so myself. You must determine the correct tap on the shielding of the cables. Only the taps of the left cable in the drawing are included in the calculation.

FROM 3 BAND TO 5 BAND

Balun 1: 4 to be able to use a 10/15/20 m staircase Yagi (FB13 + director FB23) for the WARC tires.





To test the minimum length of an antenna with Underhill's system, experiments were carried out with a 2el Yagi for 10, 15 and 20 m. The antenna is an FB13 with a director of an FB33. Before that I made a 4 ÷ 1 balun of 2 × 1.5 m RG-58 Teflon 50? Coax cable, all wrapped on a 32 mm diameter gray plastic pipe and stored in a standard sewer pipe with lids. This balun tolerated a carrier power of 1 kW for 15 minutes without problems.

As a fixed reference for comparing the different configurations of the drawing, a PA3 ... / MM station was used in the mediterranean area. Every year for a number of months a connection was made almost daily. For him I was always one of the strongest stations in the Netherlands with my two elements Yagi.

Of the Yagi, in figure a only the dipole is drawn. If the staircase system was replaced by a dipole (fig b) of the same length and fed with 1 ÷ 4 balun, then I was weaker than with (fig a) the original beam. Then a half wave (fig c) for 20 m with 1 ÷ 4 balun was mounted and that was as strong as before. Finally, the original staircase dipole was replaced and fed with 1 ÷ 4 balun. No difference was found with the original Yagi, only it was now possible to arrive at 10, 12, 15, 17 and 20 m with the aid of a tuner. As a special feature, 15 m could be worked without a tuner and with about 20 m coaxial cable was the SWR <1.5 on that band.

This 4: 1 balun was mounted as an experiment on my 2el 3 tires Yagi instead of a 1: 1 balun.

As an experiment, this "multiband antenna" with a tuner is tuned to 80, 40, 30 m and connections are made with it. That went even surprisingly well at 30 and 40 m. At 80 meters I got a report from S7 once while a station from Amsterdam with an antenna of 2 × 6 m was almost impossible to take.

CONCLUSION

Especially for residents of flats or other locations with restrictions, it is worth a try to try the Underhill system. Make the open line as long as possible and the coaxial cable as short as possible. Even those who are in possession of an antenna for the pre WARC period, can also use their antenna on the WARC tires at low cost and extra work.

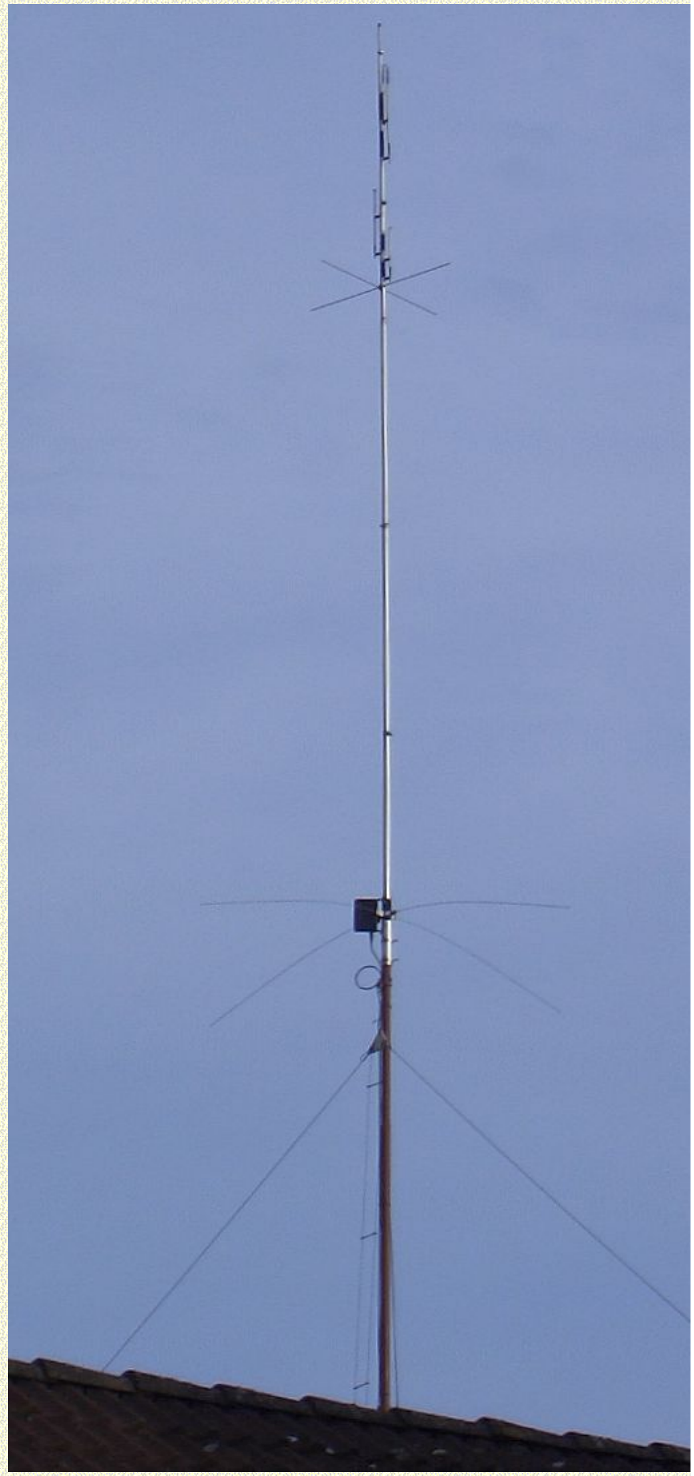
The coax balun in this article is one of the best known transformers when it comes to symmetrical feeding.

OTHER ANTENNA

The balun is also good to use with G5RV and FD3 and FD4 , especially if the set has an internal tuner. Does it not work, extend or shorten the 50? power cable between balun and tuner.

Cushcraft R5 ½ λ Vertical | Maintenance and Repair

UPDATED **10-may-2017**



R5 a 5 band vertical on top of a 12 m mast.

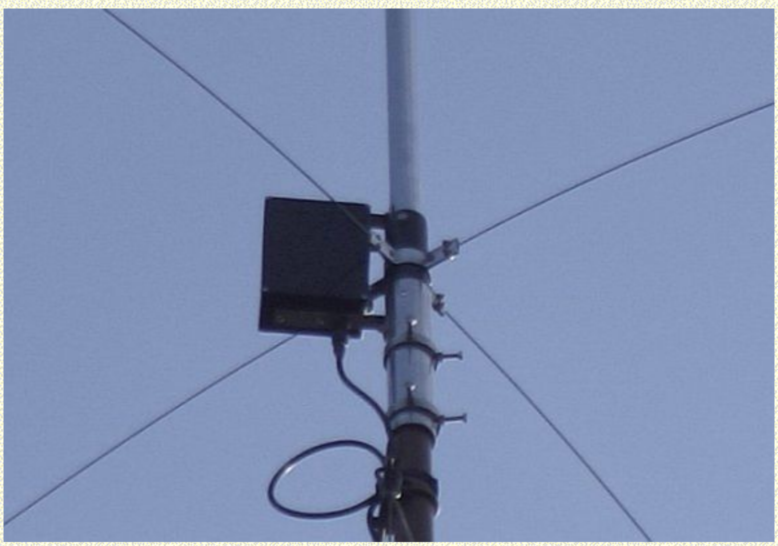
CUSHCRAFT R5 (10/12/15/17/20 m)

Cushcraft have made many vertical antennas; R4, R5, R6, R6000, R7, R7000, R8 etc. All are ½ wave radiators with 4 or shorter base-load rods. Those "radials" are in fact a top hat capacitance. The quality of the R6 successors decreased, see Product Reviews on www.eham.com.

The 17ft half wave vertical is covering the 10, 12, 15, 17, and 20m amateur bands. The antenna does not require traditional ground radials, so no need for unsightly radials and is so light a normal scaffold pole would be ideal to mount the antenna.

POWER

The manual states that this shortened half wave radiator is suited for 1.8 kW pep power and that is remarkable for this type of 5 m-tall antenna. The vertical passed a test with a borrowed 1.5 kW amplifier with no-ill effect. There were no signs of failure on the traps or matching unit.



PRACTICAL TESTS

The R5 is mounted on a 12 m mast. My 2 el. Yagi only outperforms this antenna if the beam is pointed to the station. The difference is very noticeable in SSB/CW DX pile-ups, but if I can hear them I can work them. It provides useful DX performance. I did comparisons with my open wire fed inverted V W3DZZ and on 20 m: R5 = W3DZZ at 1500 km. On all bands beyond 1500 km the signal strength is about 1 S unit better than the W3DZZ.

This antenna is very usable and, being asymmetrically fed, with no radials and only 4 × 1.24 m stainless steel whips («fig) is attractive for apartment dwellers. All hardware is aluminium or stainless steel. The aluminium durability is good but not as good as Fritzel's tubing. It has withstood many heavy windstorms without a problem and currently is bent over at about a 10 – 15 degree angle. It is rugged and not too tall mounting without guy ropes. This antenna is sensitive to metal objects in near field. Prevent installation over a metal roof or near out other antennas because they will detune the R5 considerably.

INSULATOR

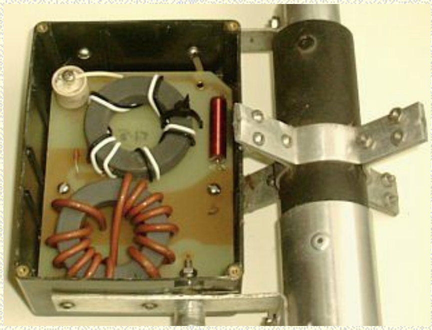
The fibreglass base insulator (fig a) is a polyester-coated tube. The polyester surface has the tendency to "evaporate" and the bare glass fibres then are like a sponge attracting absorbing dirt and moisture.

Fig a: A bare weather beaten insulator.

Fig b: An unprotected new R7 insulator.

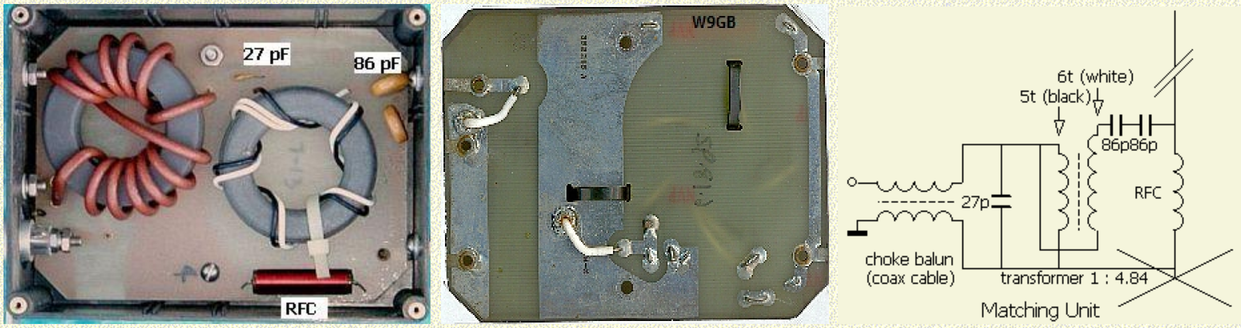
"Bumper" spray

The insulator was "painted" with layers of 2 component polyester resin and sprayed (fig») with "bumper spray", a black non-metallic spray paint. It prevents the deterioration of the polyester.



Insulator protected with black non-metallic spray paint.

MATCHING UNIT



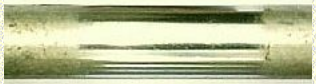
L to R: choke balun (brown colour wire) and 1 : 4.84 auto transformer (black and white colour wire).

On several homepages the transformer is called a 1 : 4 balun. That is contrary to the print design. On the auto transformer are 5 black turns and 6 white turns through the toroid. So the transformer step up ratio is 5 : (5 + 6) and that is an $5^2 : 11^2 = 1 : 4.84$ impedance ratio. All matching units' shows equally designed print boards.

I replaced the two 86 pF caps in series with a single transmitting high current 47 pF doorknob type.

This happens if one use the antenna with an ATU and a lot of power on more than the specified 5 bands!

MAINTENANCE



The traps should be carefully loosened and the contact area and all other aluminium hardware should be cleaned with Brillo pads (steel wool impregnated with soap).

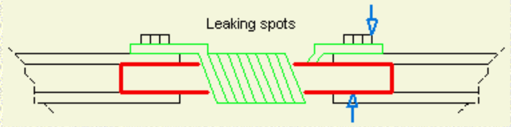
COIL

Water got inside a trap due to cracked heath shrink tubing.

Cleaned and repaired coil

I have been using my 2ndhand R5 for more than two years and then some problems arose. The SWR was varying and increased on some bands. I took the antenna down and it turns out that water got inside a trap because cracked heath shrink tubing and a split in the joint between the coil former (force-fit?) into the aluminium tube. The heath shrink tubing was carefully removed and the coil, covered with "transparent contact adhesive", was cleaned with thinner.

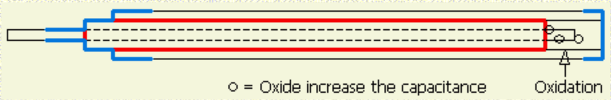
Once clean, the split should be filled with epoxy glue (2-part polyurethane adhesive), the coil buttered with transparent contact adhesive and reassembled with heath shrink tubing. The process with the transparent adhesive is for preventing that water gets inside the trap.



Leaking spots are the heath shrinks tubing over the bolt onto the connection of the coil former with the tube.

CAPACITOR

The capacitors paralleling the sealed coils are coaxial types with a rod, a tube and a dielectric tubing in between. One end is sealed with heath shrink tubing and the other end is protected with a cap.

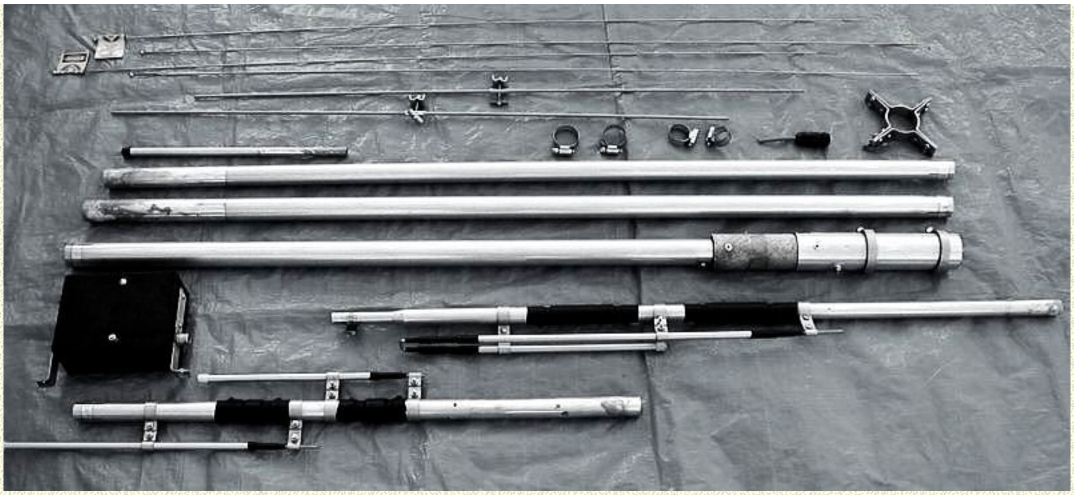


One capacitor failed because of a burst cap and water get into the coaxial system. This changed the dielectric constant of the capacitor, thus moving the resonant frequency, and the SWR increased dramatically. Flash-overs when running high power shorted the wet capacitor out and evaporated a part of the insulating tubing.

This was replaced with a short piece of PTFE tubing and all of the components were dried, cleaned and reassembled with contact cement and heath shrink tubing.

It seems that glue sticks («fig) for a glue gun are suitable for replacement of the insulating tubes.

All caps are replaced with («fig) rugged caps.



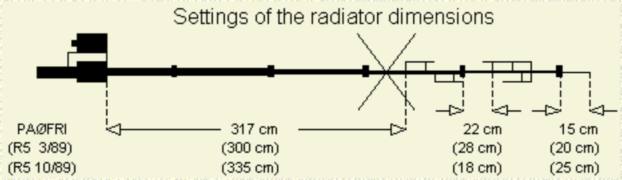
All R5 parts of the 1989 model.

Measuring the traps is only possible by comparison with another R5. Make sure that you do not touch any part of the antenna and vary the frequency of a (grid) dipper meter until a strong dip is seen. Move the meter away while retuning until a very shallow dip is seen. Take note of the trap frequency. Repeat this process with the repaired R5.

RADIATOR DIMENSIONS

The assembly and installation manuals of 3/1989 and 10/1989 show different dimensions for the radiator.

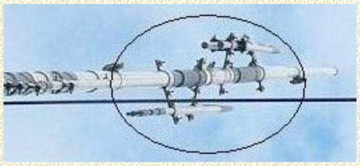
With the antenna on a 2 m mast I measured the SWR, on each band with a half wave (or multiple) 50 Ω cable for that band between the feeder point and an analyser. I found the dimensions in the schematic by varying the sections to match the specifications for SWR ~ 1



Back on a 12 m mast the R5 performs by ½ – 1 S unit better (75% of the QSO's) than the inverted V W3DZZ.	MHz	14.200	18.100	21.400	24.950	29.500
With a 12.5 m 50 Ω coax cable feeder line the SWR was:	SWR	1	1	1.3	1	1.1

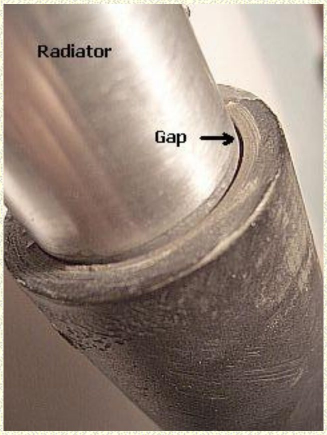
NOTE: 2 TYPES OF TRAPS FOR 15 m and 17 m

Combined 15/17 m trap March 1989



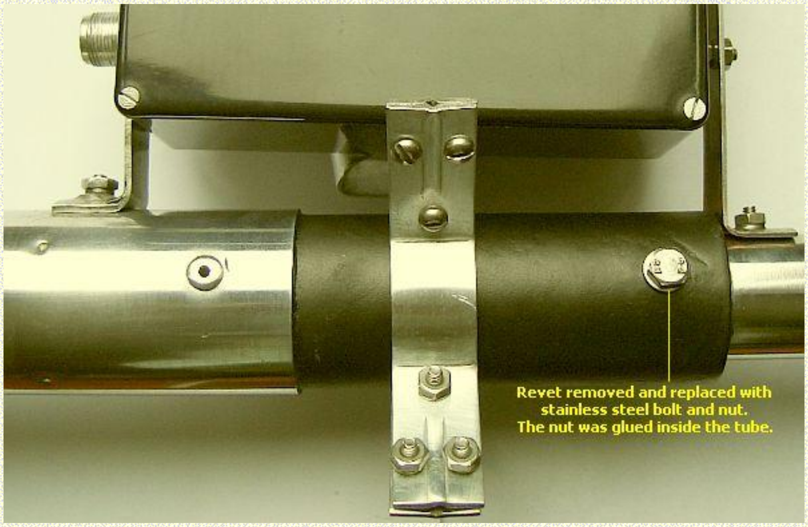
15 + 17 m traps October 1989

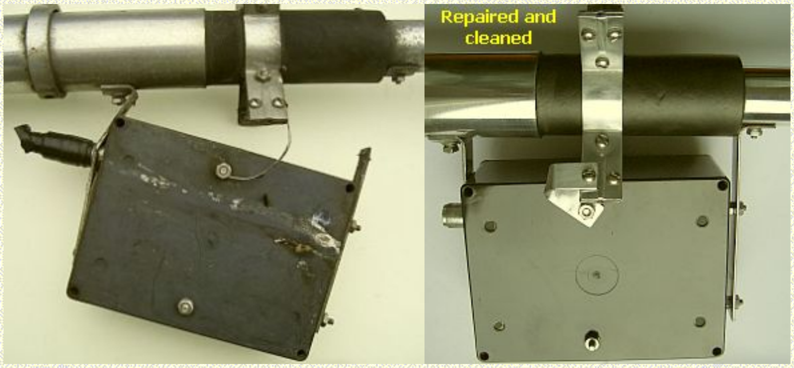
WOBBLED ANTENNA



The antenna wobbled due to the gap caused by evaporation of the polyester. The tube was removed, the inside of the insulator applied with layers of 2 component polyester resin until a minimum variation of fit. Then I sanded the insulator for a perfect cylindrically curved shape and applied the last layer and placed the antenna back in the insulator. In fact the insulator was restructured to its original diameter.

I used a polyester repair set (for automobile) and applied the 2 component polyester resin with a brush. Eventually fill holes with fibreglass. The 2 component polyester resin can be used in combination with fibreglass mat and fibreglass thin film to fill holes in surfaces of steel, aluminium, wood, concrete and polyester. Polyester resin is elastic and resistant to chemicals and weather influences and is, after hardening only sand smooth mechanically.





Due to the gap the antenna wobbled and one of the straps was broken.

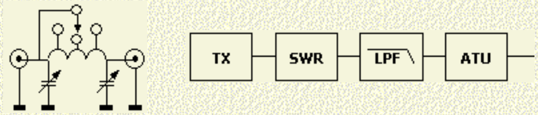
I replaced a shortcut 27 pF cap with 4 × ceramic tube caps in series/parallel.

Greg, W9GB found a potential replacement source for damaged MN-7 black enclosures.

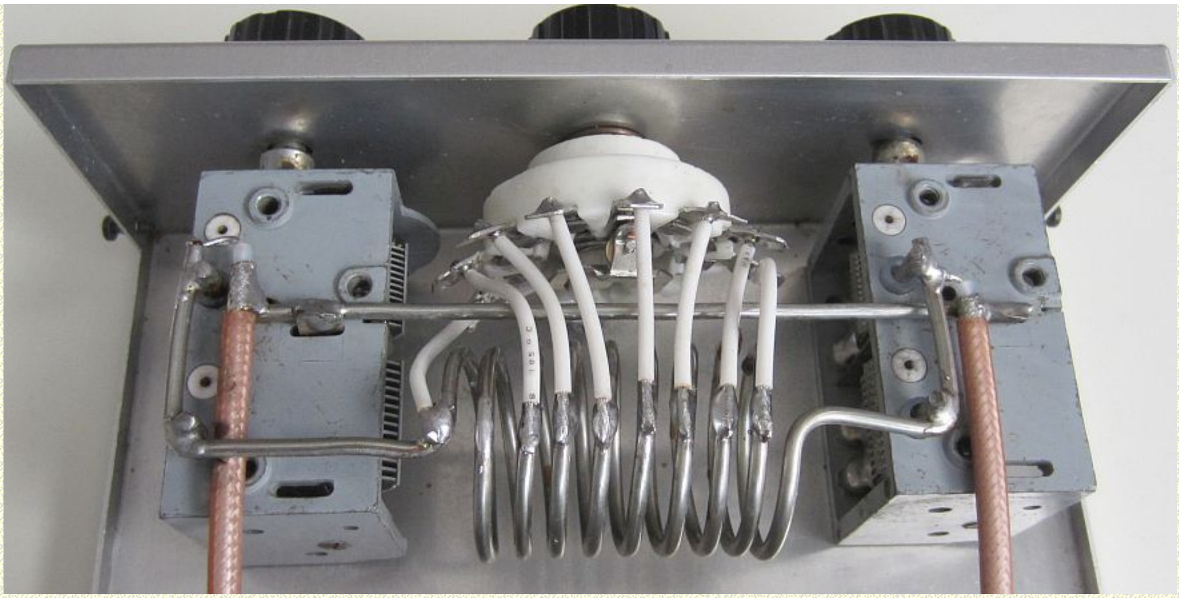
http://www.electronicsurplus.com/commerce/catalog/product.jsp?product_id=69167&czuid=1195158651593

He wrote: "I have found the a black plastic case (fig») that is identical to the MN-7 Matching Network enclosure used by Cushcraft. It appears that Cushcraft used the Polycase "EP" series, EP-8 model. The ***POLYCASE®*** EP-8 size is identical and injection mouldings from the dies are identical in every detail to my MN-7 (1992). I do not think Polycase makes the "EP" series currently. These EP-8 boxes are now surplus NOS from Electronic Surplus, Inc. (ESI) in Cleveland. OH. ESI had 441 in stock at $ 4.50 USD each -- I just received 3 to confirm match".

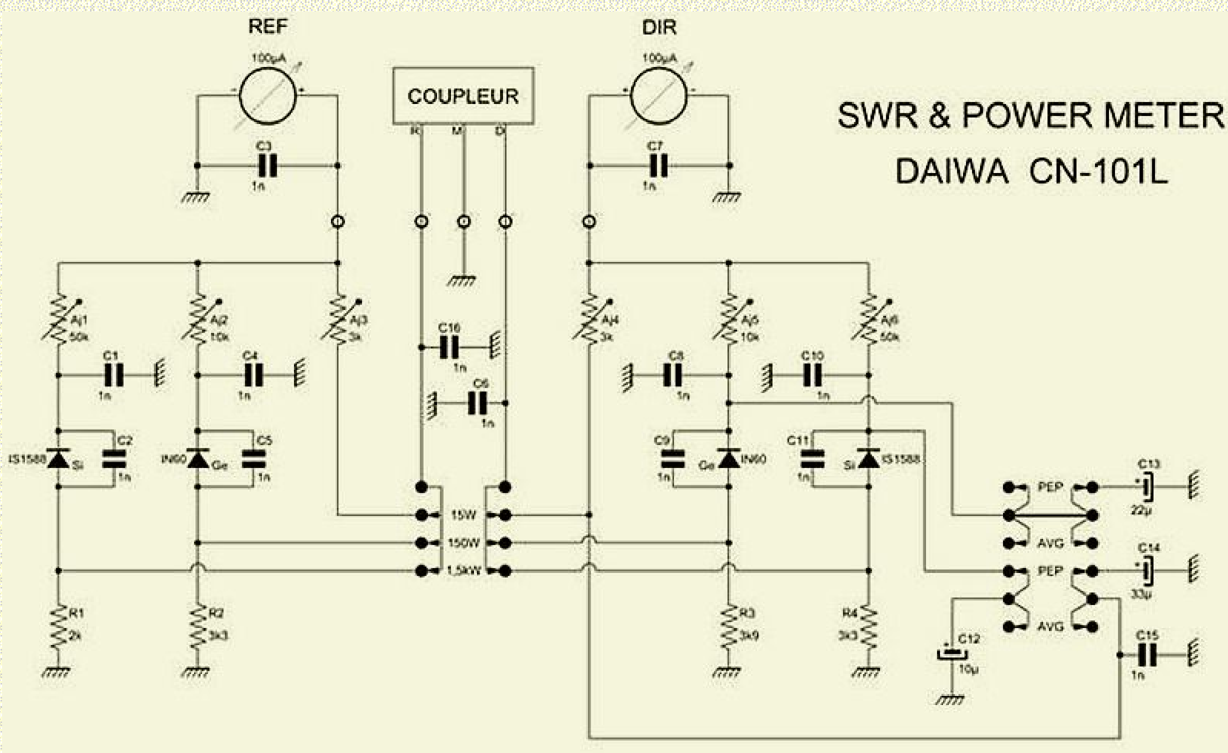
ATU

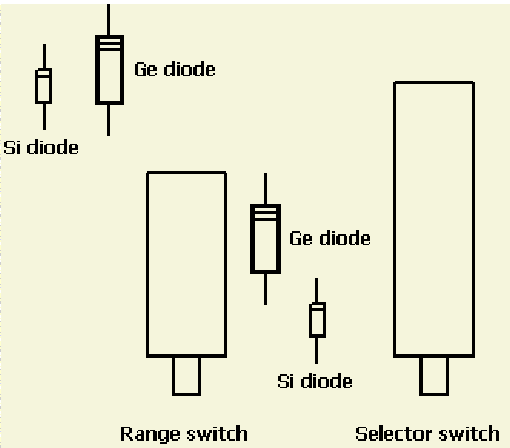


I use an easy to build pi-ATU to always ensure that the transceiver is loaded with a SWR = 1.

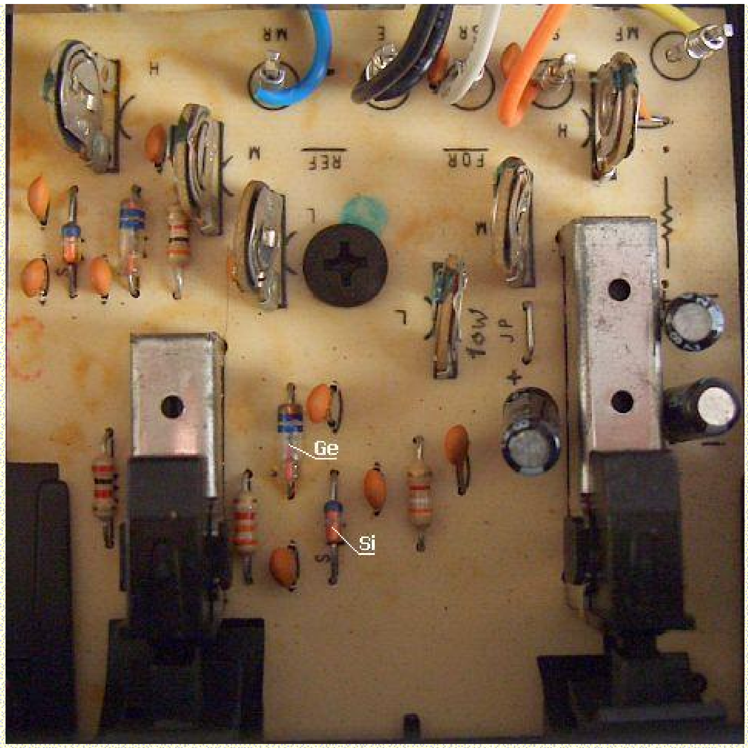


DAIWA CN-101L SWR & POWER METER





Correct positions of the diodes



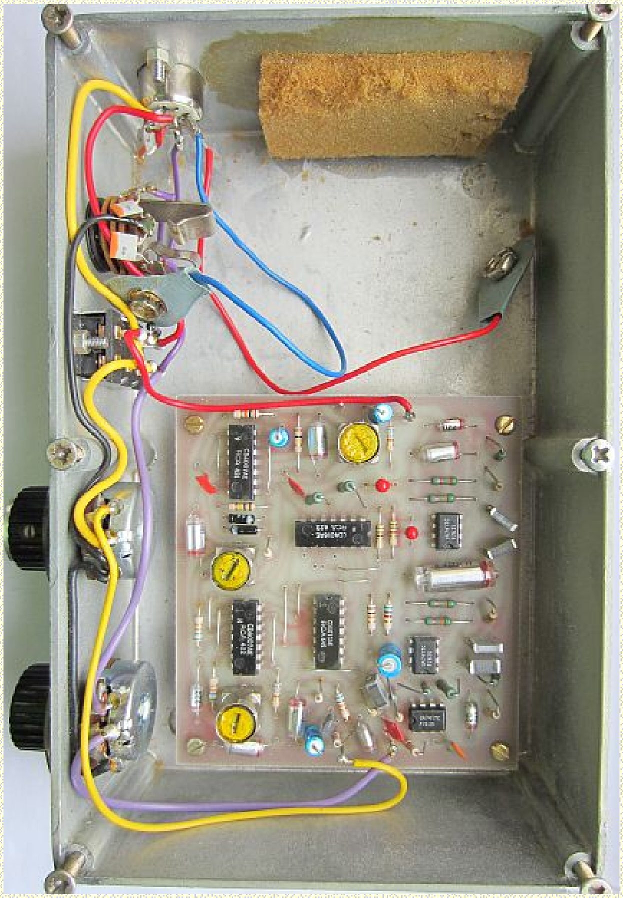
I have two CN101L's, both from different brands. One's response was extremely non-linear and it turned-out that a silicon and a germanium diode were interchanged on the PCB board. With de diodes on the proper place the meter corresponds normal. Then I calibrate both meters on 14.25 MHz on each range with a BIRD 43. The trim-pots on the board are indicated with 'L', 'M' and 'H'. The meters are now very accurate in the 80 - 15m range, they can match the BIRD. The deflection of the needle is about 10% less on 10 and 160 m.

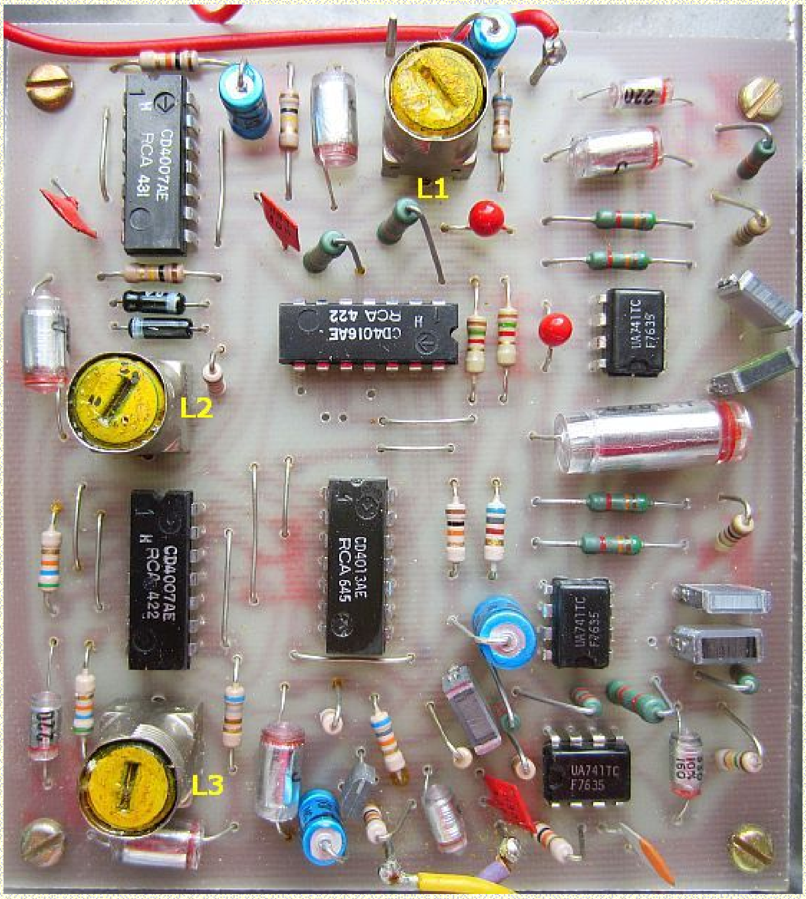
«Back AØFR

DATONG R.F. CLIPPER MODEL RFC (Blue Box)

30-jul-2014 A fault in the schematic corrected.

Vintage and working!





DATONG R.F. CLIPPER Model RFC

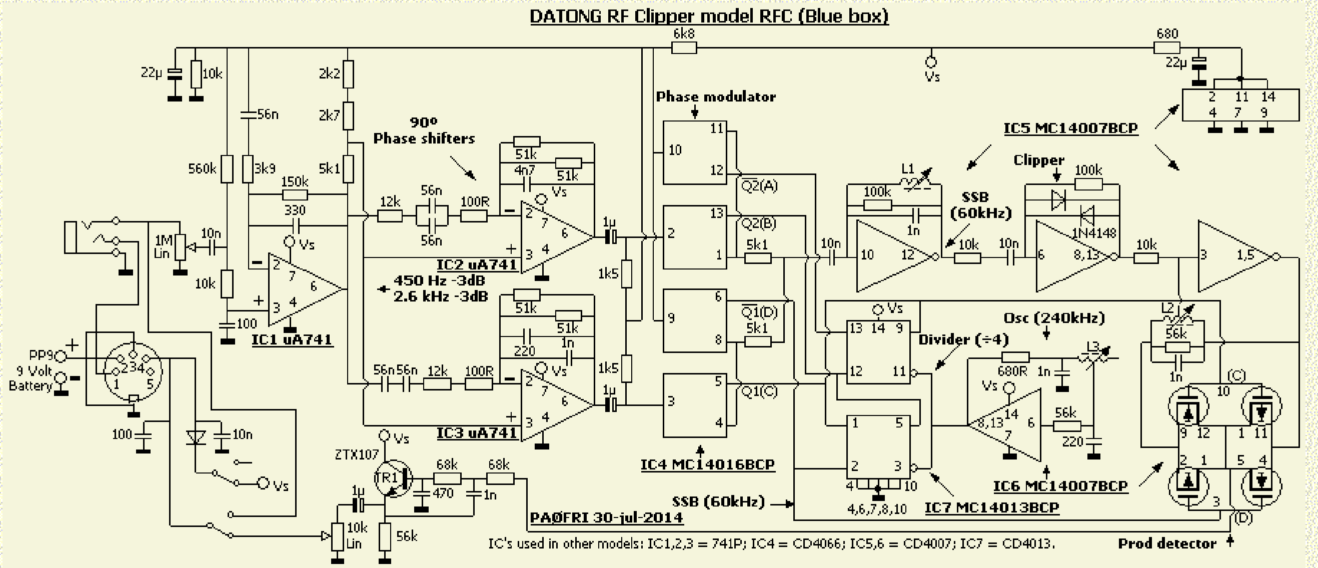
About 30 years ago Datong Electronicss Limited produced model RFC (RF) clipper in a light blue aluminium box or a fully assembled PCB as model RFC/M. Later manufacturer has stopped production for radio amateurs and has focused on products for military purposes. Therefore, one can not find complete information about the device.

INFORMATION COLLECTED FROM INTERNET

All information I could find on the Internet has been collected and compiled in this article as a reference for fellow hams. Occasionally the clipper is offered on eBay or at a flea market. Maybe it's worth for you to see if the principle is suited for a homemade RF clipper project.

SCHEMATIC

I have merged



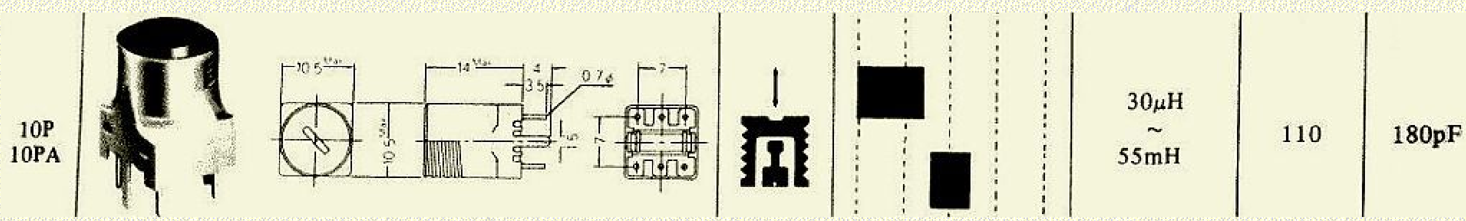
fractionated schematics on the Internet into one diagram. At first glance it seems a complicated circuit, but on closer inspection it turns out to be a simple design.

The microphone signal is amplified by IC1 and more or less limited to 450-2600 Hz (-3dB). IC2 and IC3 ensure that the amplified signal is rotated by 90 º in phase for the next phase modulator IC4.

IC6 is a 240 KHz oscillator. IC7 is divide that signals by 4 and rotated by 90 º in phase, so that a 60 kHz signal is available for the phase modulator. Further the signal goes to pin 10 of IC5, where it is filtered and amplified. At pin 12 of IC5 arises an SSB signal with suppressed carrier, where L1 is tuned to 3000 Hz ± 50 Hz. The next stage is a limiter with two diodes. IC5 then amplifies and filters between pins 3 and 5. L2 is tuned to 1700 Hz ± 50 Hz. The clipped signal from IC5 (pin 1,5) goes to the product detector part of IC6. The latter is feed by a 60 kHz signal from IC4 resulting in a original low frequency but compressed signal for emitter of TR1.

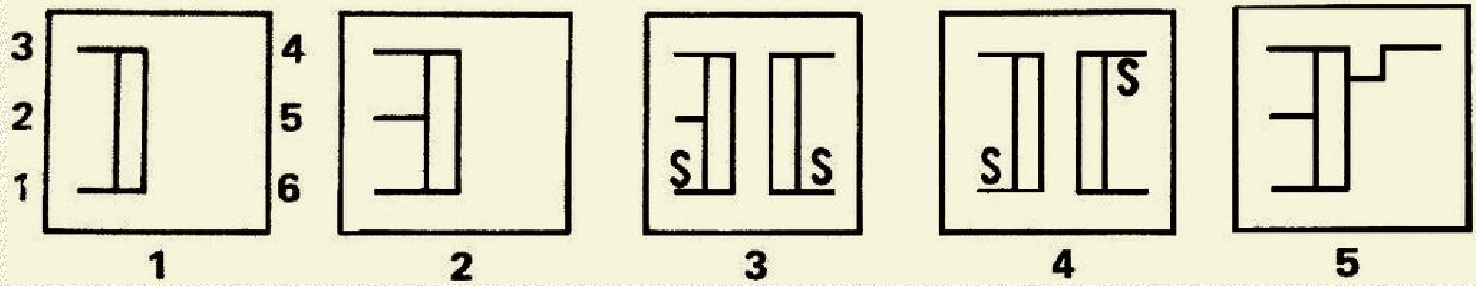
INDUCTORS L1, L2, L3

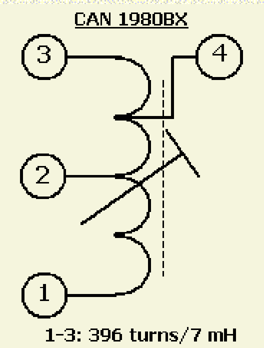
A homebrewer asked me more details about the inductors. All three (TOKO?) inductors on my PCB are marked with 1980. On the Internet https://sites.google.com/site/datongarchive/rfc I found the right information, see below.

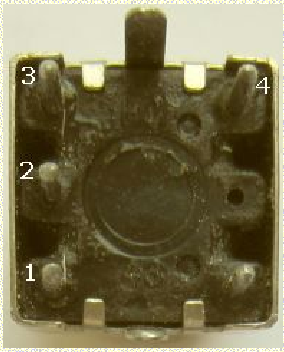


Coil Style	Type no..	Use	Colour	Q	Int. C (or L)	Winding details 1-2	2-3	1-3	4-6	other	Base No.	Comments
10PA	CAN1898HM	LF	orange	50	7mH			396			1	MPX tuning/filter coil
10PA	CAN1980BX	LF	yellow	50	7mH	40		396		1/4:198½	5	MPX tuning/filter
10PA	CAN1979A	LF	white	50	11.75mH	257	257	514	257		3	MPX tuning/filter
10PA	CAN1896HM	LF	black	85	22mH	695					1	MPX tuning/ AF filters
10PA	CLNS30568Z	LF	black	70	23mH			640			1	MPX /AF filter (Dolby)
10PA	CLNS30569Z	LF	black	100	36mH			780			1	MPX /AF filter (Dolby)
10PA	CAN1A350EK	LW	red	100	3.5mH	27	234	261	27		6	LW RF/Antenna coil
10ME	87BN134HM	LF	orange	55	7mH			349			1	See CAN1898HM
10ME	87BN135BX	LF	yellow	55	7mH	35	314	349		1/4:174	5	See CAN1980BX
10ME	87BN133AT	LF	white	55	11.8mH	226	226	452	226		3	See CAN1979A
10ME	87BN132HM	LF	black	100	22mH			618			1	See CAN1896HM
7PA	126ANSA5305	LF	yellow	55	7mH	39		349		1/4:195	5	7mm version CAN1980BX
7PA	126ANSA5306	LF	orange	55	12mH	257	257	514	136		3	7mm version CAN1979A

BASE CONNECTIONS: S = Start of Winding







DATONG ELECTRONICS LIMITED

Spence Mills, Mill Lane, Bramley,
Leeds LS13 3HE. England.
Telephone: 0532 552461

UNIVERSAL RF SPEECH CLIPPER — Alignment Details

1. Feed a sinusoidal signal at a frequency of 3000 $\pm$ 50 Hz into the unit (SKT2 "tip") at a level which is well below the clipping threshold (see note 7). Adjust the core of L1 for maximum output signal at SKT 1 (pin 3), reducing the input level if necessary to avoid the onset of clipping.

2. Repeat the procedure with the core of L2 using an input frequency of 1700 $\pm$ 50 Hz.

3. The setting of the core of L3 determines the frequency of the internal oscillator. Its setting is arbitrary, although once L1 and L2 have been adjusted as described above, L3 must not be altered. The nominal frequency at pins 8 and 13 of IC6 is 240 kHz, and at points A,B,C,orD it is precisely one quarter of this, i.e., 60 kHz. Good square waves with each of the four quadrature phases exist at these four points. The actual oscillation frequency is not critical and is not controlled

during manufacture.

Suggested Checking Procedure

1. Apply an input signal, preferably a sinusoid with frequency between 300 and 3000 Hz.

2. An amplified replica should appear at pin 6 of IC1.

3. Pin 6 of IC2 and IC3 should provide a pair of replicas (mutually phase shifted by 90°) of the signal at pin 6 of IC1. The signal amplitudes at IC2 and IC3 are slightly lower than at IC1.

4. The two signals at pins 4 and 11 of IC4 should appear identical except in relative phase, and should comprise "chopped" versions of those at pin 6 of IC2 and IC3.

5. The signal at pin 12 of IC5 should be a single sideband suppressed carrier signal at the nominal 60 kHz and with a low level of residual carrier (the carrier is typically well over 50db below peak signal at this point).

6. Pin 8 of IC5 should carry an amplified and clipped version of that at pin 12. The amplitude of residual carrier should be less than 25% of the clipped signal peak amplitude.

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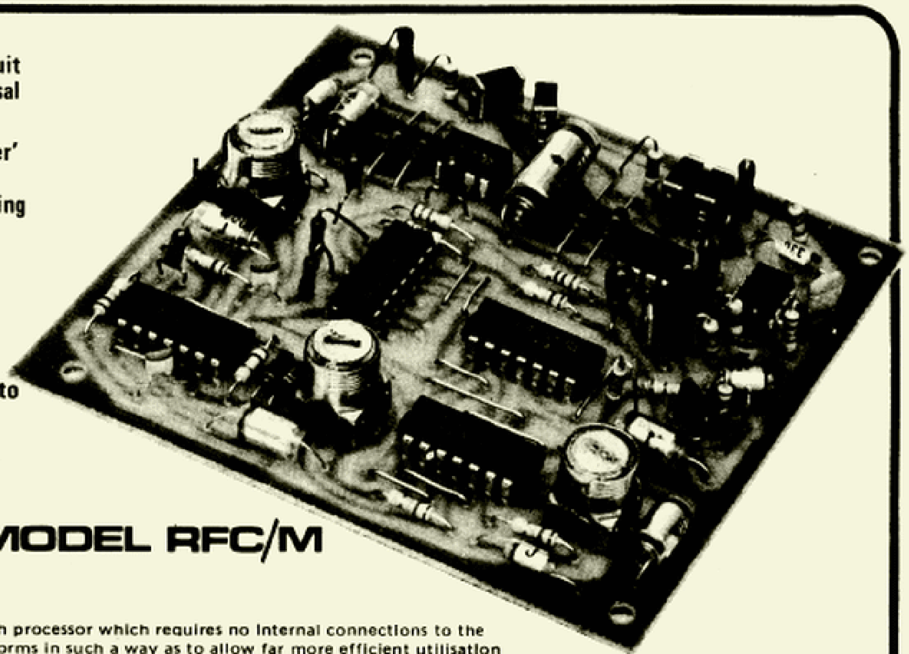
- A fully aligned and tested printed circuit module as used in the Datong "Universal r.f. Speech Clipper".
- Greatly increases 'punch' or 'talk-power' when connected between microphone and transmitter, yet, without introducing harmonic distortion.
- Ideal for use with SSB, AM, or FM transmitters.
- Advanced circuit uses seven analogue and digital integrated circuits.
- Very wide supply voltage tolerance (6 to 15 volts) and low current drain.
- Glass-fibre P.C. board and professional quality components.



MODEL RFC/M

FUNCTION

The module is a radio frequency speech processor which requires no internal connections to the transmitter. It processes speech waveforms in such a way as to allow far more efficient utilisation of the peak modulation capabilities of conventional radio transmitters, and to give increased intelligibility in difficult reception conditions. In effect the transmitter becomes equivalent to one with a peak power rating (or deviation) up to about ten times greater, yet distortion introduced by the device is subjectively negligible.

DESCRIPTION

The Datong r.f. speech clipper module first translates the incoming speech frequencies up to a frequency of 60 kHz as a single sideband suppressed carrier signal. This SSB signal is amplitude limited and filtered and then re-translated back to audio frequencies. After low-pass filtering the r.f. clipped audio signal appears at the output terminal with a well-defined peak amplitude which is independent of the amplitude of the input signal.

Compared with devices which clip the audio input signal directly, this advanced method of speech processing has the advantages that the distortion is subjectively negligible and that the output is quite suitable for driving SSB as well as AM and FM transmitters. Compared with a.g.c. type audio frequency compressors the Datong r.f. speech clipper does not suffer from limitations due to finite response time and gives significantly better enhancement of "talk-power." *

* These differences are discussed in more detail in the following articles by Dr. D. A. Tong (G8ENN), "A.f. and r.f. clipping for speech processing", Wireless World, February 1975, pp 79-82, "The r.f. clipping advantage", Short Wave Magazine, October 1974, pp 422-426.

When the Datong r.f. clipper module is correctly used the results are comparable to those obtained using a linear amplifier with 6-10db power gain. This applies at any operating frequency and even if you already run full legal power. In the case of FM or AM you sound much louder and more intelligible for a given peak deviation or modulation depth and this is of great benefit when operating near the limits of range.

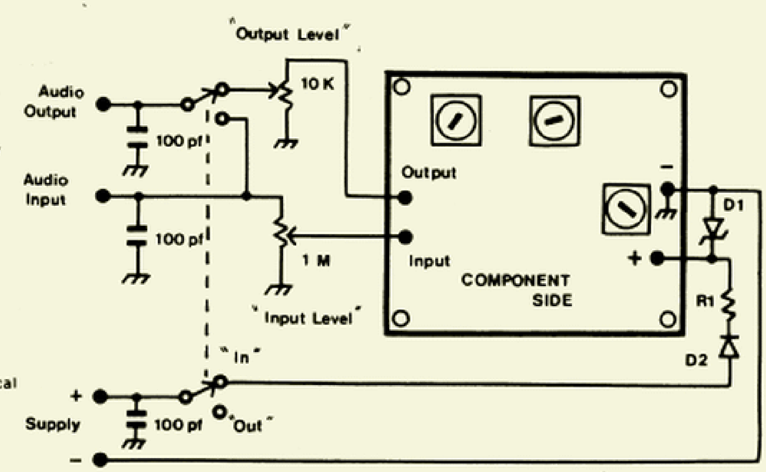
WIRING AND MOUNTING INSTRUCTIONS

The following connections must be made to the module: power supply, audio input, audio output.

Two solder terminals are provided for the power source, the one for the negative line being connected to system ground (the peripheral copper track on the P.C. board). Therefore if the module is powered from an external supply it must be one with "negative earth". With systems having a "positive earth" a separate 9 volt battery should be used for the module.

Connections to the module are shown on the diagram, together with peripheral components. The 10 volt zener diode (D1) and resistor R1 are used to ensure that the power supply voltage seen by the module never exceeds 15 volts, even transiently. These components should always be used when the module is operated from the electrical system of a car. The value of resistor R1 is calculated from

$$R1 = (V_{in} - V_{zener})/10 \text{ Kilohms}$$



If there is no possibility of the power supply voltage exceeding 15 volts, even transiently, D1 and R1 may be omitted. Almost any low power zener diode in the range 8-10 volts is suitable, for example the BZY88C10V.

The series diode, D2 provides protection against accidental reversal of the power supply polarity. Such protection is not built into the basic module and is strongly recommended. Almost any silicon diode can be used, such as 1N916, 1N4148, 0A200, etc.

The 1 megohm input potentiometer shown on the diagram allows the output from the microphone to be adjusted so as to give the degree of clipping required. With the potentiometer omitted or set to maximum, the microphone must give 80 mV peak-to-peak (typical) for 20db of r.f. clipping. The majority of microphones in current use give more than this. The load resistance presented by the clipper module is nominally 560K.

The 10K output potentiometer allows the 400 mV peak-to-peak output voltage from the module to be reduced if required to suit the actual input sensitivity of the transmitter. If the output potentiometer is set to maximum, the external load resistance should be greater than 4K, but if the potentiometer is reduced to less than half-way load resistances down to zero can be applied (although there will be a corresponding reduction in the output voltage from the module).

The "in/out" switch shown on the diagram is optional and allows the input signal to by-pass the clipper module if desired. It also functions as an "on/off" switch for use with a battery power supply.

When the module is used with a transmitter it must be shielded from strong r.f. fields otherwise severe distortion or even continuous oscillations will occur when transmitting due to pick-up and rectification of r.f. energy by the low-level audio stages. The extent of shielding required will depend on the actual situation but it is strongly recommended that the module be mounted, using the brass pillars supplied, inside a completely enclosed metal box. The input and output connections should also be decoupled to r.f. by 100 pf ceramic capacitors as shown on the connection diagram. To be effective the capacitors should have lead lengths less than about 1 cm, and should be mounted with one side connected to the metal case and the other to the input or output connector.

IMPORTANT NOTE:

The tips of some soldering irons may have an alternating potential with respect to mains earth due to internal leakage. In severe cases the potential could exceed the maximum supply voltage rating of the module. To avoid any possibility of damage to the module the following precautions should be taken: (1) Make sure that the soldering iron is earthed; (2) Make a direct connection from the tip of the soldering iron to the negative supply voltage terminal on the module; (3) Disconnect the module from any other equipment when soldering to the terminals.

No responsibility for damage or malfunction can be accepted if any soldering is carried out to points on the module other than to the four solder tags provided, or if any unauthorised attempt is made at modification or repair.

OPERATING INSTRUCTIONS

When the unit is wired as described above the method of setting the controls and of using it with a transmitter is the same as with the normal Datong "Universal r.f. speech clipper" and the same instruction sheet is supplied with the module as with the complete ready-to-operate units.

TECHNICAL DATA

(Except where stated, the data quoted represent typical values obtained using a supply voltage of 9 volts).

Input sensitivity at 1 kHz at clipping threshold (Note 1)	8mV pk-to-pk
Input impedance	560K shunted by 82 pf.
Output at clipping threshold	400mV pk-to-pk
Degree of r.f. clipping obtainable before the input stage begins to limit (Note 2)	26 db
Signal-to-noise ratio at clipping threshold	45 db
Frequency response for inputs below clipping threshold	-3 db points at 450 Hz and 2.6 kHz
Supply voltage range (Note 3)	6 to 15 volts
Supply current	18 mA at 15 volts, 12.5 mA at 12 volts, 8 mA at 9 volts, 4 mA at 6 volts.
Minimum External Load for full output	4K
Dimensions	90 x 98 mm. Height above board 13 mm.
Fixing centres	80 x 85 mm.

Notes

1. The clipping threshold is reached, by definition, when the output is 3 db below its maximum level
2. More than 15-20 db of clipping is not normally required.
3. The upper limit should not be exceeded even momentarily. The negative side of the supply is connected to the peripheral copper track and hence to the mounting pillars.
4. The right is reserved to vary these parameters in the light of continuing development.

UNIVERSAL R.F. SPEECH CLIPPER

INSTALLATION AND OPERATING INSTRUCTIONS

These notes are intended to be read in conjunction with and to augment the basic information given on the product data sheet.

INTERCONNECTION

1. **The output lead.** Suitable ouput leads are available from Datong Electronics Ltd. as optional accessories and allow the clipper to be plugged directly into many different makes of transmitter. These leads are wired according to the pin connections shown in the block diagram on the clipper data sheet. Pin 3 of the 5 pin DIN plug carries the output signal from the clipper and pin 1 carries the push-to-talk line. Each of these two wires is separately screened with the screens connected together at pin 2 of the DIN plug. Pin 2 is also connected to the shell of the plug. Pins 4 and 5 are joined within the plug so that the internal battery is brought into use when the lead is plugged in.

2. **The input socket.** Many transmitters already use a standard stereo-type jack for the microphone connection. A microphone fitted with such a plug will connect directly to the Datong Clipper (assuming the connections are the same). In other cases either an adaptor lead will have to be used, or the microphone plug will have to be replaced by a jack plug. It should be wired as shown in the block diagram, i.e. with the microphone lead to the "tip" and the push-to-talk lead to the "ring". The sleeve is the common earth return. If the existing microphone plug is changed to a stereo jack plug, the original plug can be fitted to the end of the clipper output lead. A suitable ready-made lead is then RFC/FREE.

SETTING THE CONTROLS

In order to obtain the best results with the Datong Clipper (or any other) it is important that it be used correctly and this requires some appreciation of the quite different functions of the two level controls on the clipper. The key difference between them is that the "output level" knob controls the signal level **after** the clipping process, whereas the "input level" knob controls the amplification of the microphone signal **before** it is processed and subject to r.f. clipping. This is indicated on the block diagram.

Because the clipping stage defines a fixed upper limit for any input signal above the clipping threshold, the "input level" control has no effect on the **peak** output amplitude; instead it controls the degree of clipping. It has, therefore, a large effect on the **average** amplitude of the output signal.

The "output level" control on the other hand should be regarded as a preset control which, when the clipper is switched to "in", has the same effect as the microphone gain control on the transmitter. It is included as a convenience to the operator since it allows the peak output from the clipper to be set equal to the peak output from the bare microphone. Operation of the "in/out" switch then allows a direct comparison to be made of the effectiveness of the clipper. Note that in the "out" position the microphone is connected directly through to the output socket and the internal or external battery is disconnected.

1. **Setting up for SSB without using test equipment.** Having installed the clipper as already described, switch to "out", and tune and load up the transmitter and set the transmitter microphone gain control in the normal way for negligible "flat-topping". The microphone gain control should subsequently remain fixed.

Then switch the clipper to "in", set the "input level" control to maximum and "drone" into the microphone. Adjust the "output level" control on the clipper until the P.A. anode current meter indicates the peak value recommended for the particular transmitter. Finally, reduce the setting of the "input level" control until the desired degree of clipping is achieved (see later).

If the transmitter has an a.l.c. meter it is probably better to use the recommended a.l.c. meter reading rather than the P.A. anode current reading as the criterion for setting the gains in the above procedure.

When the clipper/transmitter combination has been set up in the above manner it is wise to ask several fairly local stations to check the transmitted signal for "splatter". Slight "flat-topping" can go relatively unnoticed when no speech processing is used but can cause annoying interference to others when speech processing is used because then the peaks occur for a much larger fraction of the time. The optimum setting for the "output level" control is that which gives the highest P.A. anode current consistent with no splatter.

Once correctly set up, the Datong Clipper ensures that no matter how loudly you talk into the microphone the transmitter will not flat-top.

2. **Setting up for SSB using an oscilloscope.** If an oscilloscope or other device to detect the occurrence of "flat-topping" is available, proceed as follows:

(a) Set up the oscilloscope to monitor the output signal from the transmitter.

(b) With the clipper switched to "out", "drone" (rather than whistle) into the microphone and adjust the microphone gain control on the transmitter until "flat-topping" is only just apparent on occasional peaks.

(c) Do not readjust the transmitter gain control. Switch the clipper to "in", set the "input-level" control to maximum, and again "drone" into the microphone. Adjust the "output level" control on the clipper until "flat-topping" just fails to occur on peaks. Note that the oscilloscope trace shows a far higher average output level than when the microphone is used alone.

(d) Adjust the "input level" control to give the desired degree of clipping.

3. **Setting up for AM transmitters.** The procedure is in general the same as already detailed for SSB except that AM transmitters normally have no means of monitoring the modulation depth. As in AM operation without a speech processor, the important thing is to use as large a depth of modulation as possible without over-modulating on peaks. The ideal way to check this is with an oscilloscope, but failing that, a good indication is obtained by checking for the absence of "splatter" adjacent to the transmitter frequency.

If the transmitter is fitted with a modulation limiter the output level from the Datong Clipper should be adjusted so that the limiter just fails to operate on peaks.

4. **Setting up for FM transmitters.** The same comments apply as for AM except that for "overmodulation" read "overdeviation". Also of course an oscilloscope is of no value in setting up the deviation.

CHOICE OF CORRECT CLIPPING LEVELS

This is best found by experiment since it depends on the characteristics of both the voice and the microphone. A setting of the "input level" control can be found where the sensitivity to weak sounds is the same with either setting of the "in/out" switch. This represents the situation where the extent of clipping is slight. As the "input level" is increased further from this point, more clipping occurs and the average reading on the P.A. anode current meter will increase. This represents part of the gain in talk-power.

The greater part of the considerable talk-power gain achieved by clipping occurs with the first 10 to 15 db.

A good way to get the feel of what the "input level" control does is to feed the audio output from pin 3 of the output socket into a tape recorder. Test recordings should then be made with various settings of the "input level" control.

When signals are very weak it is worthwhile using the maximum available clipping since any slight changes in voice characteristics will be completely masked.

SUITABILITY OF MICROPHONES

The input characteristics of the Datong Clipper were chosen to suit the large majority of microphones currently in use. The sensitivity of the input is high: only 8 mV peak-to-peak (i.e. 4 mV peak, or 2.8 mV r.m.s. sine wave) are needed to reach the threshold of clipping. It follows that 80mV peak-to-peak on voice peaks is sufficient to give 20db of clipping. This is probably the maximum which will be required. Most ceramic or magnetic microphones are suitable. It is helpful to speak more closely into the microphone when using speech processing in order to suppress room echo and background noises.

BATTERY REPLACEMENT

The battery should be replaced when its voltage has dropped to 6.5. Its voltage is easily monitored at pin 4 of the output socket without opening the case of the clipper. Although the clipper may still appear to work at supply voltages as low as 4, the dynamic range of the input amplifier will be reduced and this will introduce harmonic distortion.

EXTERNAL POWER SOURCES

When an external power supply is used note the following points: (a) The "in/out" switch on the clipper still operates normally. (b) The clipper is still protected against the application of reversed power supplies. (c) The absolute upper limit for the supply voltage is 15.5 volts. Supplies greater than this require that a dropper resistor be connected in series. A suitable value in Kilohms is given by (Battery voltage−12) /8.5. (d) When operating the clipper from a 12 volt car electrical system a 10 volt zener diode should be connected with its anode to pin 2 and cathode to pin 5 of the DIN socket. The positive lead from the supply should then connect to pin 5 via a resistor of 680 ohms (¼ watt). The function of the diode is to protect against transient high voltages.

SOME GUIDELINES AND GENERAL NOTES FOR SSB APPLICATIONS

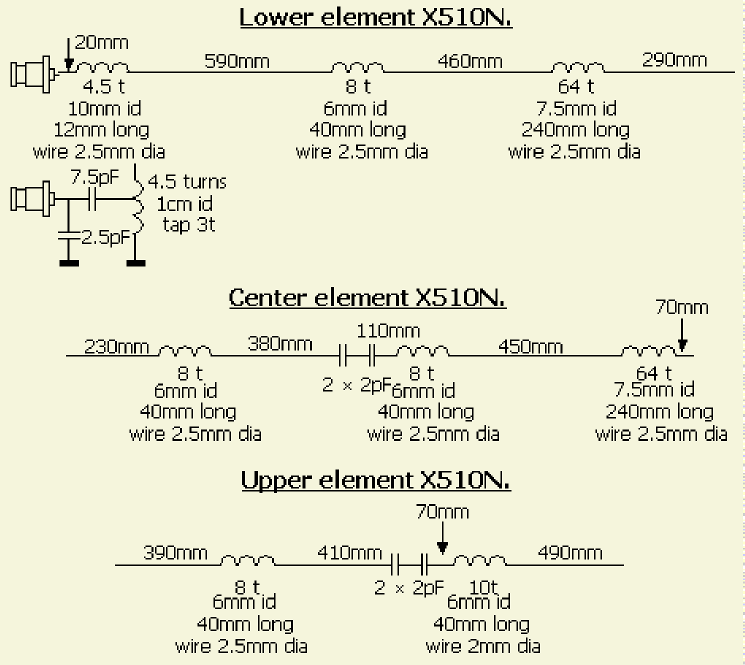
1. Many operators of SSB transmitters develop a habit of controlling the level at which they speak by monitoring the "kicks" on the P.A. anode current meter. If this is done when the clipper is in use its effect will be cancelled out. One must get used to seeing the meter spend most of its time near to its peak reading. Remember that once the system is set up correctly it is impossible to "splatter" by talking too loudly.
2. If the general opinion of receiving stations is that the clipper is having only a slight effect, it may be (a) because the "output level" is set too low, or (b) because it is set too high and the transmitter a.l.c. is operating too heavily, or (c) because when operating the transmitter with the clipper "out" you are talking-up the peak P.A. current to a higher level than the clipper allows when it is switched "in". Remember that "peaks" of P.A. current as monitored using the P.A. current meter are always substantially underestimated because a meter is too sluggish to respond properly to short duration peaks. When the clipper is "in" the meter gives a truer indication because the peaks occur so much more frequently. Thus if the P.A. current kicks up to the same reading with the clipper "in" or "out" the peak power output from the transmitter will be considerably higher with the clipper "out" and a pessimistic assessment of the value of the clipper will be obtained.
3. In SSB applications the amount of clipping which can be safely used depends on the average-power capability of the transmitter. Excessive clipping can reduce the life of the output valve(s) with a marginally rated transmitter, but any improvement in cooling efficiency around the output stage will be of direct benefit. Transmitters with blower cooling generally have better safety margins than those without. Initially it is wise to monitor P.A. temperatures until the capabilities of the transmitter are known.

It is important that background room noises are not amplified to such an extent that the transmitter is heavily modulated when speech is not present. This can be checked easily by watching the P.A. current meter. It is of great help to talk very closely into the microphone so that the "input level" control can be reduced for the same degree of clipping. Not only does this help to protect the P.A., it also helps to suppress room echo.

Obviously the output stages of the transmitter will be working harder when clipping is in use, therefore if the transmitter is only marginally rated, try to help by leaving longer gaps between sentences or words and reserve the higher clipping levels for use when really needed.

DIAMOND X510N MODIFICATION

14 feb 2013 With the correct drawning of the center element (tnx LW7DNJ).

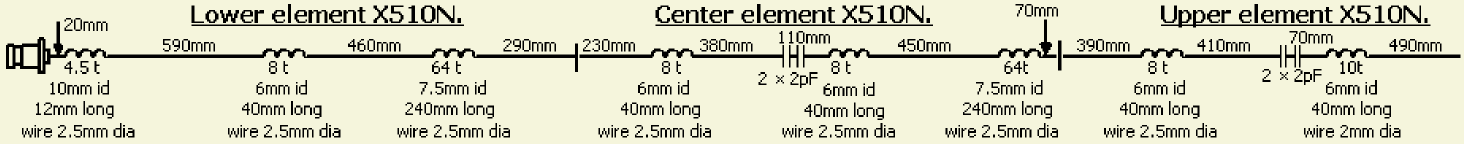


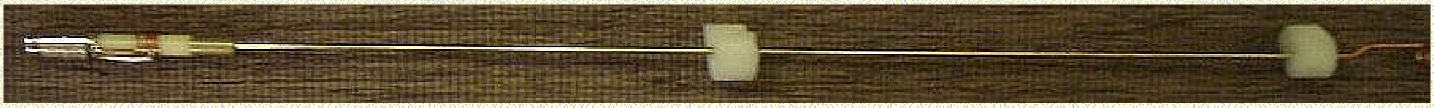
INTRODUCTION

When visiting a flea market I have been tempted by an offer to purchase a new Diamond X510N 2m/70cm antenna. For the price it was almost impossible to homebrew such a solid antenna. To handle the packaging the antenna is made in three elements.

The radiator (fig ») is mounted in a fibreglass radome, tapered like a fishing pole and finished with white lacquer. The coils are made with copper wire and aerial parts of 3 mm brass rods. To avoid rattling the radiator was (coaxial) fitted with foam plastic sleeves at approximately equal distances. The radiator is easily removed from the fibreglass poles and the sizes of the radiator elements are mentioned in the headline of this article. The total length of the antenna is 5.20 m. The antenna can bend in high winds and that disturbs the vertical polarization. So the transmitting and receiving signal strength is subject to instantaneous differences. In the Netherlands the X510X therefore is called a "calm weather" antenna. On the Internet enough positive information is published about this model, so I will confine only some details.

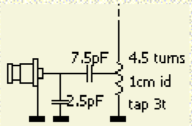
THE NAKED TRUTH





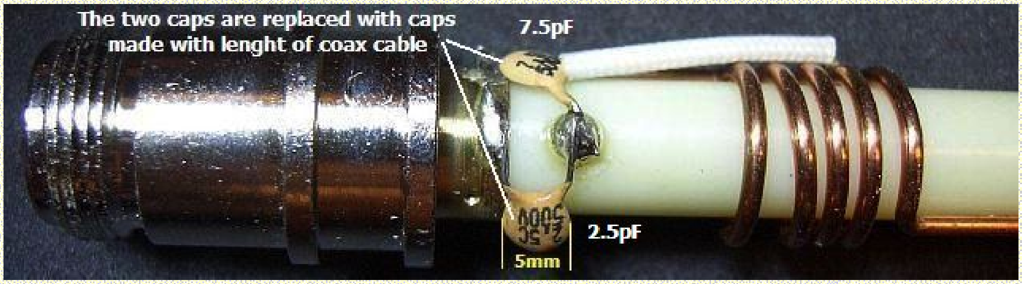
The Bottom of lower element until the 8 turns coil.

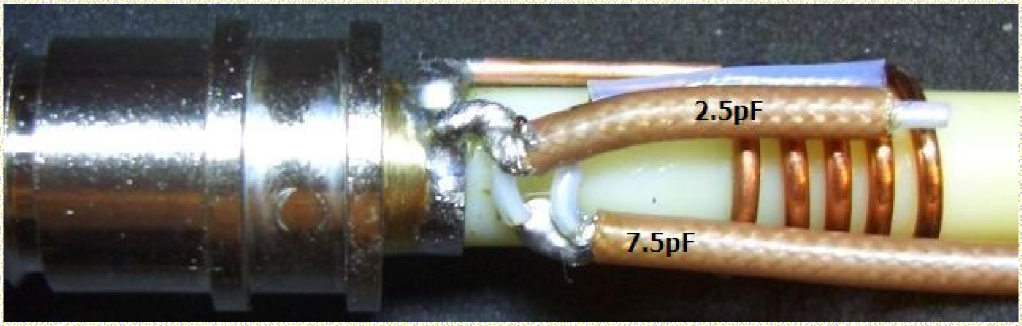
MATCHING

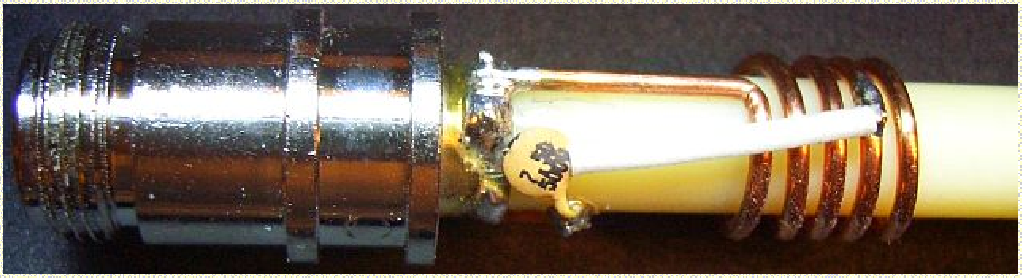


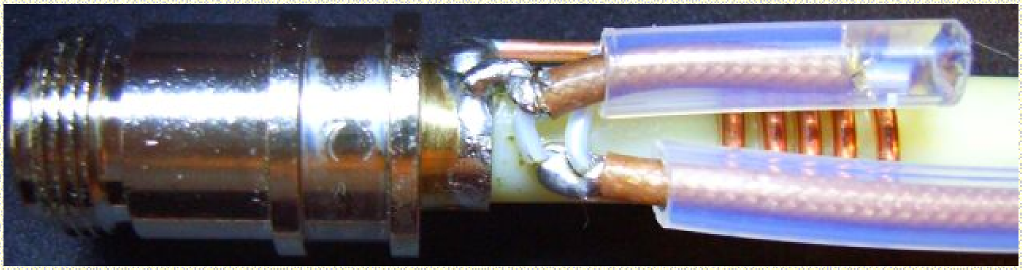
The base of the antenna is loaded with a coil of 4.5 turns and 1 cm inner diameter. The input is matched to 50 Ohm with a 7.5 pF - 2.5 pF capacitive voltage divider connected to the third winding of the coil. According to the specifications the maximum power is specified as 200 W. Not clear if that is true for both FM and SSB/CW. On the Internet one can read that no more than 35 to 50 W is recommended, which is understandable if you see the small 500 V/5 mm diameter ceramic capacitors.

Out of curiosity, the antenna was disassembled so it was only a small step to replace the capacitors. Given the limited space between the coil and the metal tube at the bottom, it was not possible to use transmit or kV capacitors. Therefore, I used 50 Ohm Teflon coaxial cable and cut the cable to the correct frequency using a capacitance meter. If you do not have the meter, a better choice is to buy good quality capacitors.









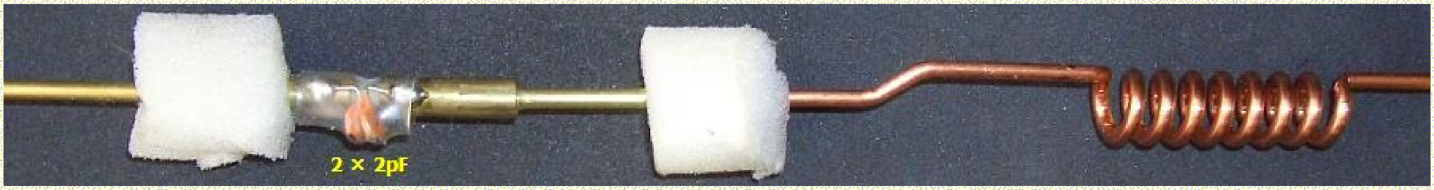
Another Teflon tube was slid over de quasi capacitors to reduce the stray capacitance. A preliminary test showed the SWR on the two bands was not more than 1.5, which is in line with the original specification.

Freq.	144	145	146	430	435	440	MHz
SWR	1.4	1.2	1.0	1.35	1.5	1.35	MHz

The test was repeated on a 1.70 m pole in the backyard. See the corresponding SWR («fig) in the table. Later the antenna was mounted (fig») on the chimney and the SWR stays identical.

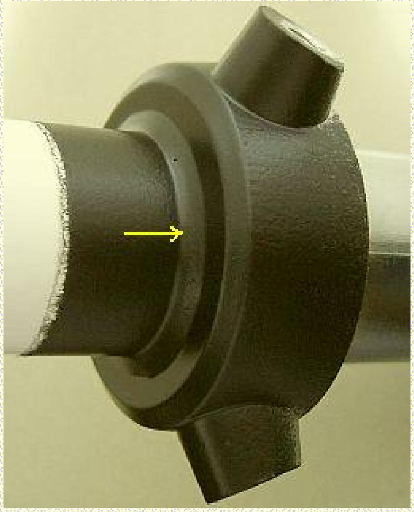
By loosening the socket-head screw («fig), which is secured with an adhesive, you can remove the inside to the right. It is recommended first heat the screw with for example a soldering iron and then unscrew.

RESONANCE



Coils and capacitors in series (fig») with the internal radiators primarily determine the resonance of the antenna. I have not replaced the small capacitors, because the energy they have to deal is much less than at the base part of the antenna. To be sure the compression fittings/joint couplers in each element were soldered.

WETHER PROTECTION



The radome is glued into the Feed Point section, but on the boundary (« see arrow below) of metal and polyester is not covered with paint. My experience with a Cushcraft R5 is that 2 component polyester resin can "evaporate" under the influence of sunlight.

The spot was sprayed with "bumper spray", a black non-metallic spray paint. All my antennas are treated with this product, because after years it proved to be a good protection.

The elements are assembled with joint brackets. For perfect waterproof the joints are covered with self vulcanizing tape and sprayed with silicone spray. The white paint was also protected with the silicone spray.

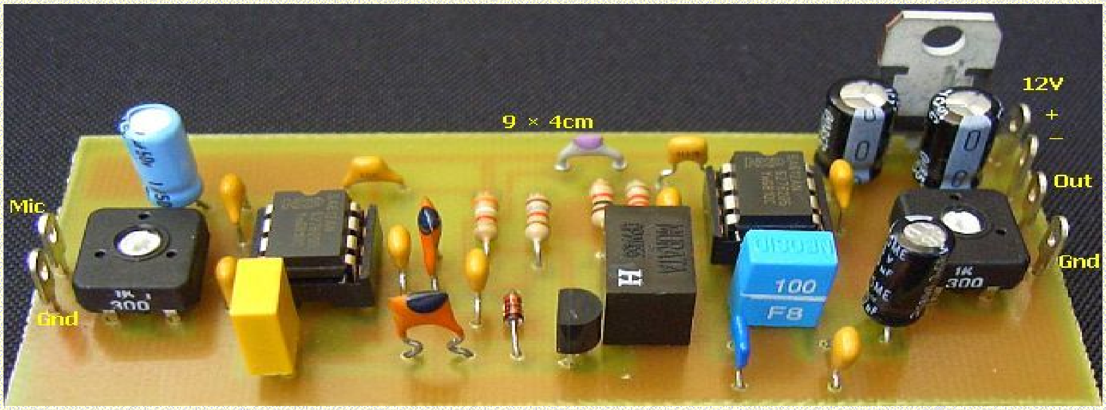
«Back
AØFR

A LIMITING RF SPEECH PROCESSOR

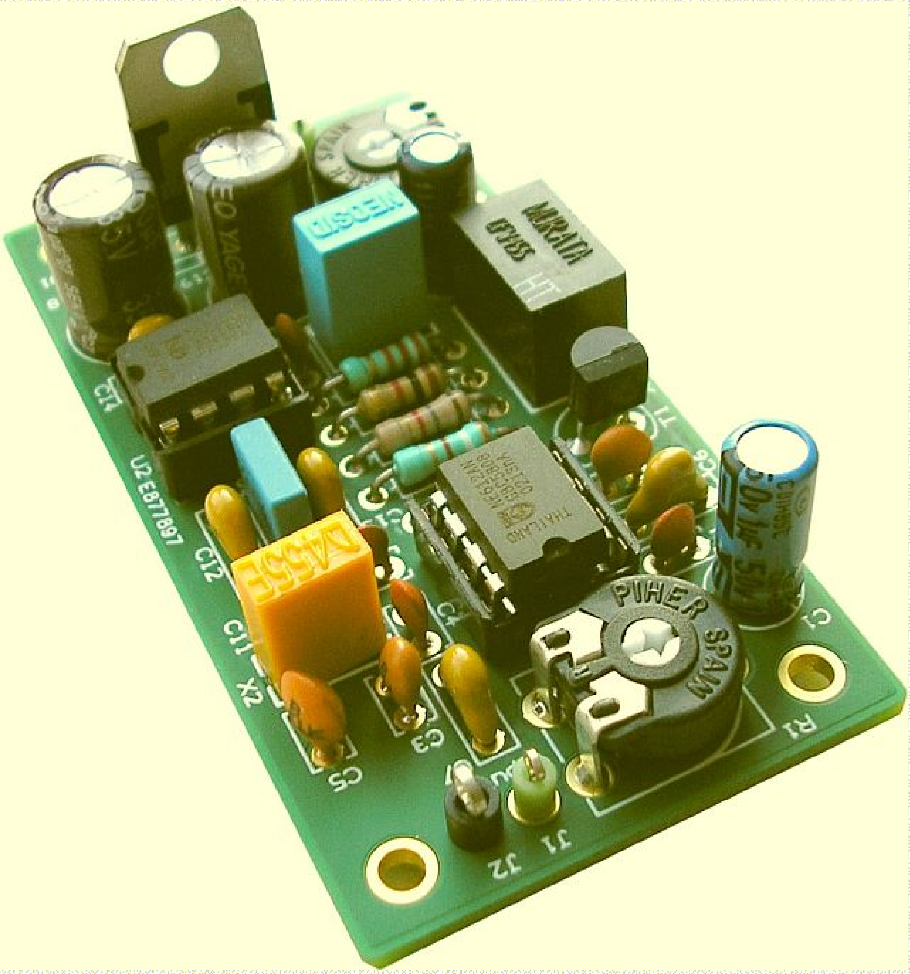
A simple system based on double-sideband limiting and selection with one filter.

Experiments and a simple working design.

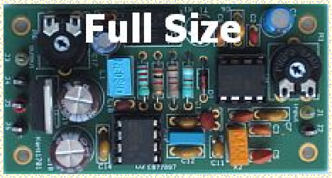
27 jan 2017: New PCB [18 jul 2011: 2 Photo's.]

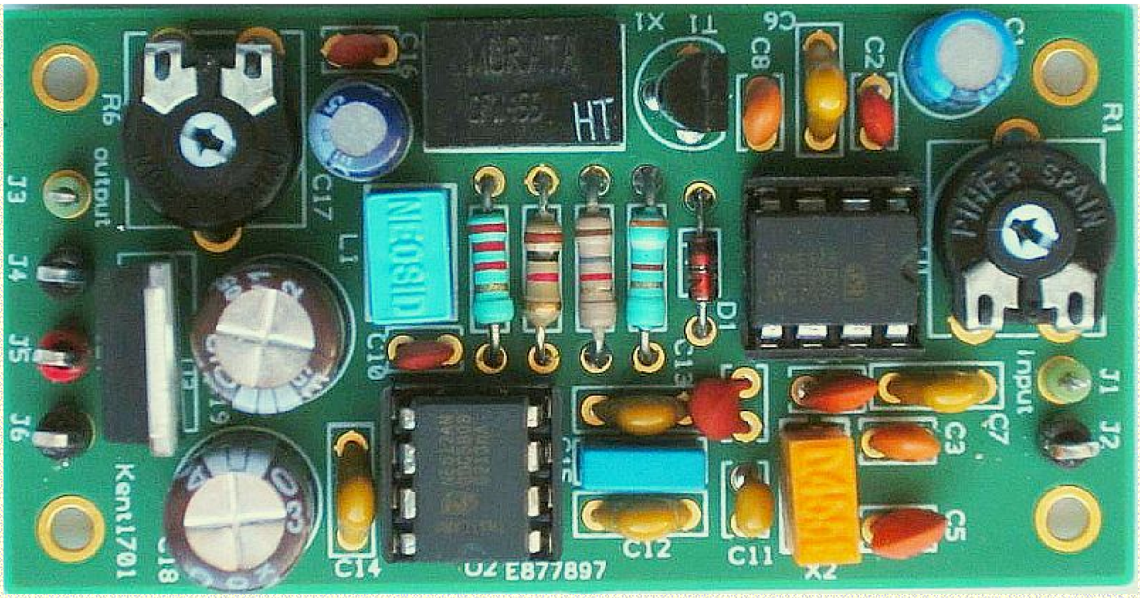


Rinus the owner of KENT-Electronics is SK

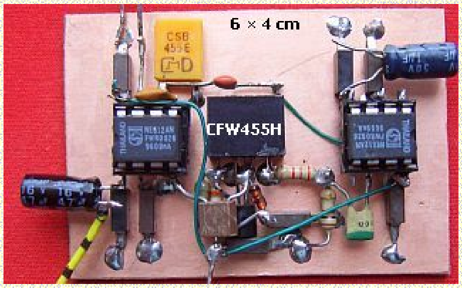


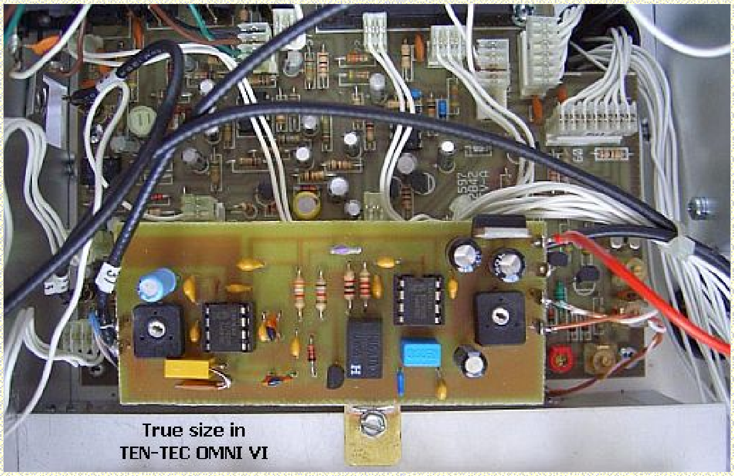
This PCB (printboard) designed by PAØMBJ is on request available by him: PA0MBJ@veron.nl.





INTRODUCTION

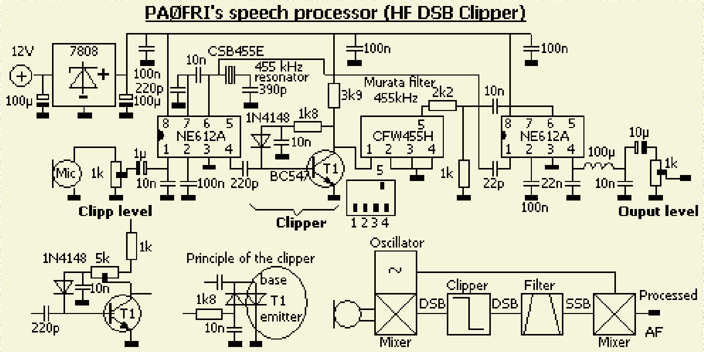


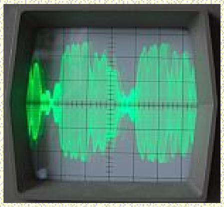


The DSB limiter in my original article (see at the bottom) gave problems for some foreign home brewers. Probably by using a different type of IC (eg TBA120S, TBA120AS, TBA120T, TBA120U) than the previous model (TBA120, TBA120A) which was used in my circuit. Moreover, the older types are difficult to obtain. Reason why I started experimenting with readily available mixer NE612A (or SA12AN). This experimental version («fig) of a speech clipper, one of the many tested designs, worked satisfactorily. See also Atlas speech processor.

DESIGN

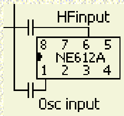
The double sideband signal from the first NE612A (pins 4, 5) is too weak to be limited with two silicon or Schottky diodes without idling current. During experimenting arose a clipper circuit with a diode and the emitter-base junction of a transistor (T1) as second diode. The 1k8 and 3k9 resistors are used for the best possible symmetrical clipping. Eventually can be replaced by a 5k0 potentiometer and 1K0 resistor to refine symmetrical clipping. The transistor contributes the necessary amplification for the ceramic filter CFW455H. This 455 kHz type must be loaded at input and output with 2k0 impedance, which I did at first. However no marked difference was noted with the higher values in the diagram.





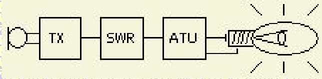
The intention is that the diodes clips and not the second mixer. With sufficient signal from the filter, the second mixer limits rather than the diodes. Therefore the filter is loaded with a voltage divider (2k2, 1K0). This («fig) can be seen on an oscilloscope with aaahhh ... into the mic.

Note that, unlike the designs of others, oscillator and RF signals are respectively routed to pins 1 and 6 of the second NE612A. I did this for more LF output at pin 4. The clipping level is determined by the strength of the microphone signal. Extreme limiting must be avoid to



maintain a good understanding. Optimal is a higher average power output while the listener does not notice that a speech processor is in action. The S meter moves much less.

The increased average output is noticeable. Use (fig») a 230 V/100 W lamp as transmitter load and tune with an ATU for SWR = 1. Speak into the microphone without processor and then enabled clipper, see the lamp show's more light.

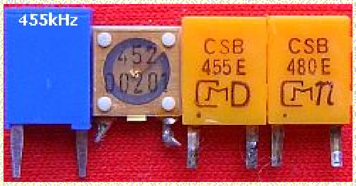


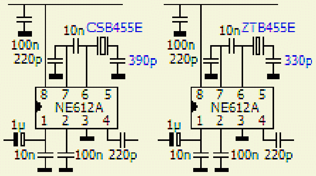
FILTER

The Murata 6 kHz/6 dB, 18 kHz/50 dB CFW455H filter («fig) is selected as a compromise between bandwidth and price. The type is obsolete, but is still available via internet (ebay.de, ebay.co.uk). More modern versions with the same specifications and with the addition of "H" (eg CFWLA455KHFA-B0) are also suitable. Alternatively, an expensive and narrow SSB filter type CFJ455K13 may used.

RESONATOR

A (fig ») 455 kHz ceramic resonator is used for the oscillator circuit. Unfortunately, they seldom resonate at the specified frequency.



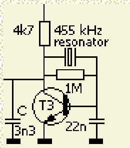


Experimentation is often needed even with items of the same type and brand. I chose for a Murata CSB455E, this model is more in circulation.

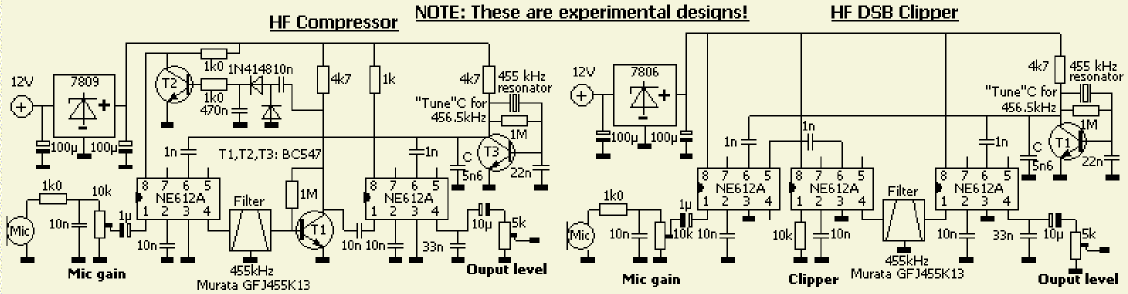
Some vendors offer («fig) a ZTB455E resonator, probably a newer version of the CSB455E type.

Experiment with the capacitance in series with the resonator for optimum modulation. For example use first a 470 pF variable capacitor.

Depending on the resonator's oscillation frequency the filter's output signal is SSB with suppressed opposite sideband or partly suppressed opposite sideband. Almost perfect SSB is obtained if the carrier is set to 452 or 457 kHz, which favour to the last frequency. Unfortunately the CSB455E does not oscillate on 457 kHz in this design. If the resonator doesn't start try (fig») the transistor oscillator of the next designs (C = 3n3 - 5n6).



OTHER DESIGNS



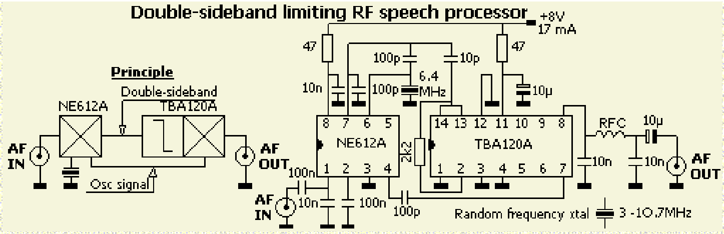
Both are experimental!

For your information here are a few of my other and possibly interesting designs. At left a compressor where T2 is used as voltage-actuated device and thereby regulates the gain of first NE612A. At right a clipper system with a third NE612A as limiter. Both systems work, but because the previous simple version performs, these circuits are not (yet) "polished".

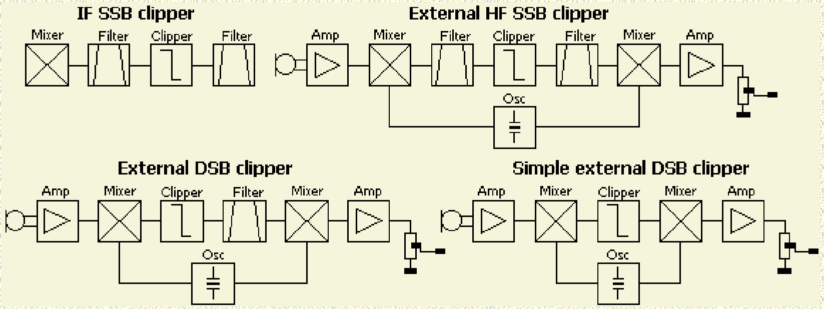
The original article

A Double-Sideband Limiting RF (HF) Speech Processor

A simple system based on double-sideband limiting without RF filters.



SPEECH PROCESSOR



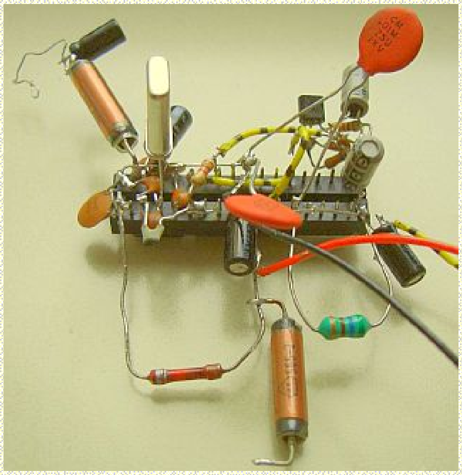
An audio or RF speech processor will give your SSB signal valuable extra "punch". An audio clipper simply either compresses or clips (or both) the audio signal. This actually ends up making your speech less intelligible, because it produces in-band distortion products. If you clip a signal, it creates harmonics, put simply 800 Hz » 1600 Hz, 2400 Hz and so on. This can (and often does) result in 'whiskers' or splatter which make the transmitted signal wider.

Converts audio signal into dsb signal, clips & processes it for greater average envelope power

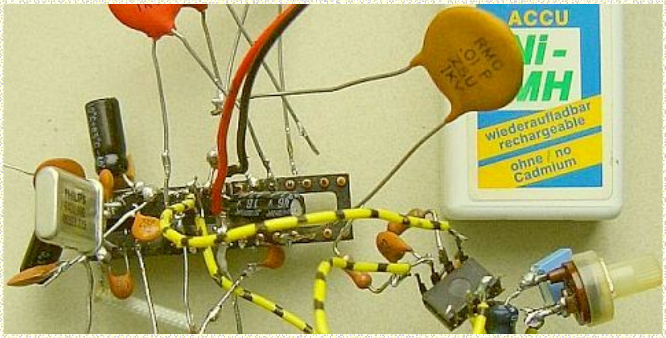
Converts signal back into audio

Adjustable levels of processing & output,

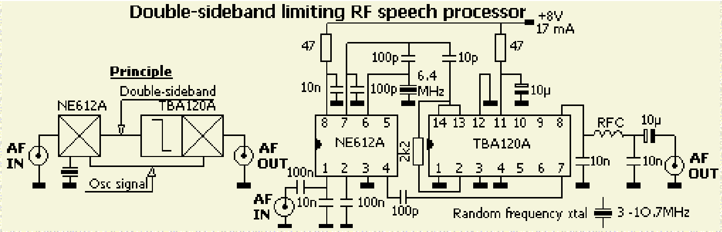
RF speech processing avoids this issue by converting the audio to a double-sideband (DSB) RF signal before clipping or compression. Any distortion produced will be harmonics of the RF frequency used. If the RF processor uses 6.4 MHz then the harmonics would be 12.8 MHz, 19.2 MHz etc., which are easily filtered out using a narrow band filter. The RF is then demodulated back to audio again. This gives a cleaner sounding signal for the same amount of compression or clipping and a 6 dB improvement (one S-unit) in RF SSB output power is possible.



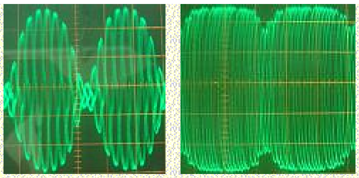
Testing designs with NE612A, CA3028A and TBA120A.



An SSB clipping processor is ideal, although somewhat expensive and complex. A double-sideband limiting processor was constructed and evaluated against an SSB-Clipper. Experimental evidence showed that the DSB-Limiting scheme performed as well as the SSB-Clipping processor when the clipping level was not excessive.



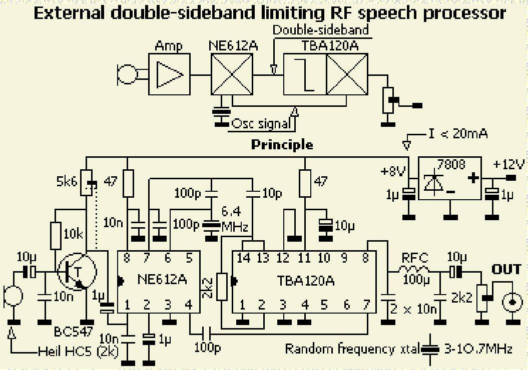
Saving RF filters with this kiss speech processor.

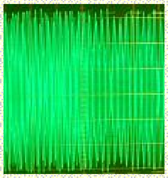


Two tone output pin 8 TBA120.

Left: linear, right: symmetrical clipped.

Double-Sideband RF Speech Processor





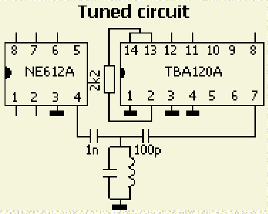
Output tx: with aahhh... into the microphone.

This Double-Sideband RF Speech Processor takes the audio from the microphone and converts it in a NE612A to an internal 6.4 MHz DSB signal. The signal is then clipped in a TBA120A and is further converted back to audio for input to a transmitter or transceiver. The resulting harmonics (of 6.4 MHz) are filtered out with simple RC filtering when it was demodulated back to audio. The result is a 'cleaner' clipped signal being finally transmitted. This increases the average output level of an audio signal from a microphone by clipping off the excessive signal peaks. By lowering the peaks in proportion to the average level, a higher average output level can be attained with an associated increase in intelligibility under difficult conditions. It is set up easily without special equipment because no RF filters are used. It can be used with any make of rig, requiring only signal connections to and from the normal microphone socket. This effective design offers microphone level input and output adjustments. The clip level depends on the amount of microphone gain.

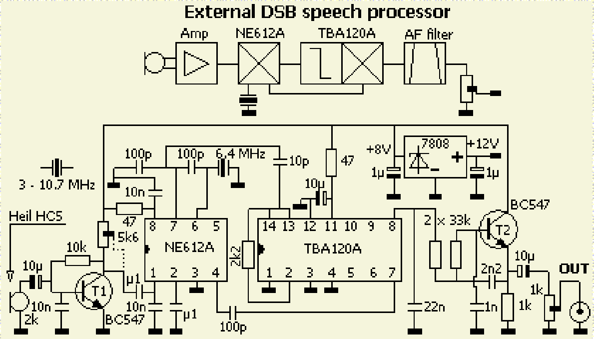
The ALC meter indication may not be quite as high as when the processor is off. This is normal, as the average power output is higher with the processor, although the peaks are being clipped of the loud or hard sounds to eliminate overdrive that leads to spurious and harmonics. It is possible to set the controls so that the peak envelope power reaches the desired level without activating the ALC at all.

The level then is only a few tenths of a dB below the level that would have been set by the ALC, but the transmission is a lot cleaner while maintaining very high average modulation.

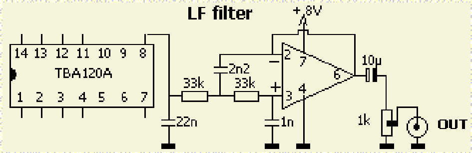
CIRCUIT IDEAS



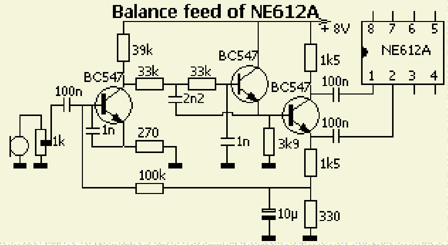
Eventual a tuned circuit.



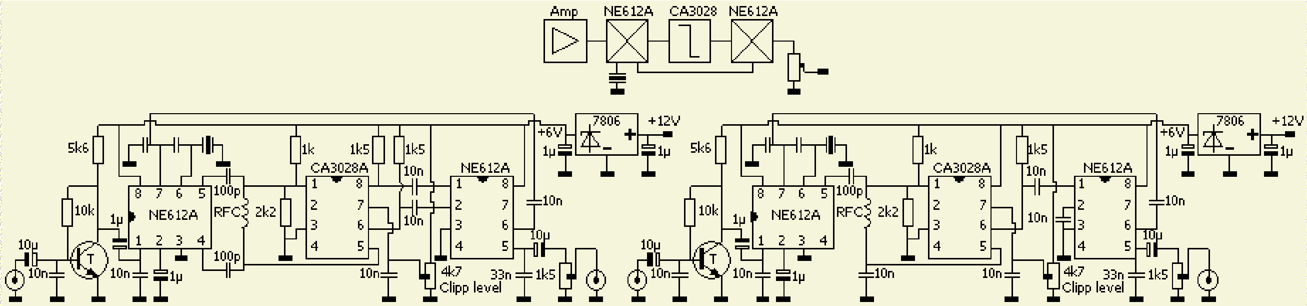
With audio band pass filter.



Audio band pass filter.



Balance input for the NE612A.

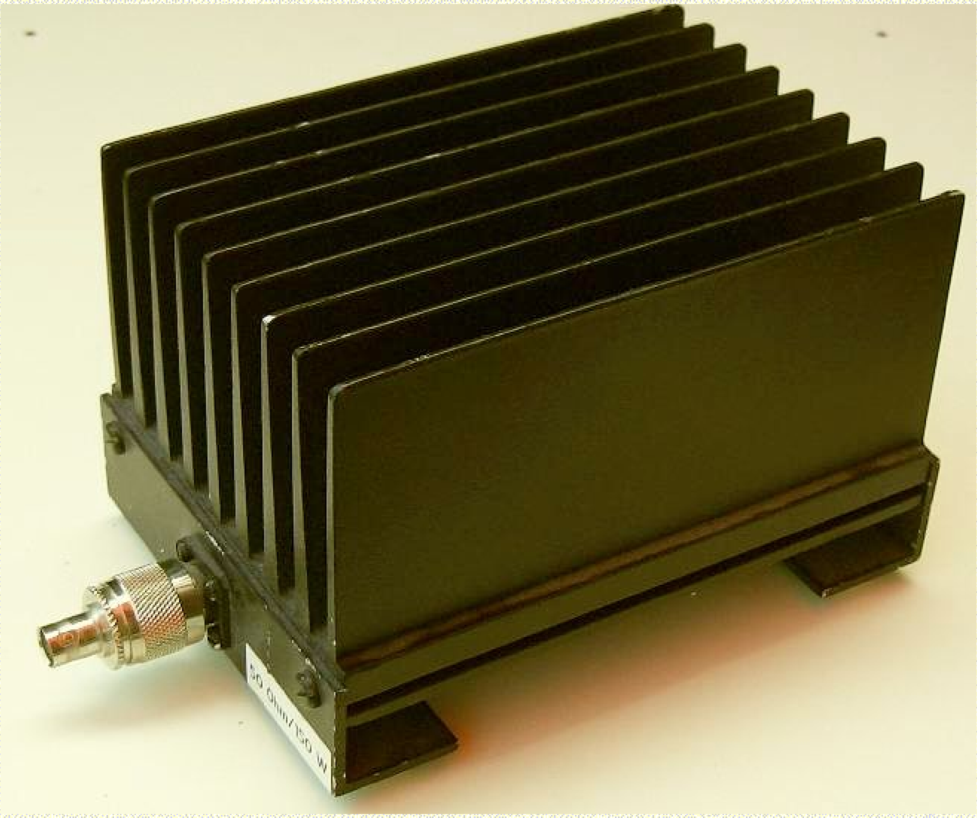


These 2 circuits are not fully tested.

«Back

Dummy load with a 50 Ω stripline (hybrid) resistor.

UPDATED 15-04-2013 With een second example of a construction.



A homebrew 50 Ω 150 Watt dummy load.

50 Ω DUMMY LOAD

Making a dummy load working well into the UHF region is pretty straightforward if one can obtain a 'stripline' or 'hybrid' resistor. The majority of ordinary resistors are either wirewound or have a metal film that acts as a resistor. These have some inductance resulting in bad SWR. They may just work on 160 meters but not on VHF/UHF.

STRIPLINE (OR 'HYBRID') RESISTOR.

Thick film resistors (e.g. made from aluminium nitride ceramics) exists in many shapes and power ratings e.g. (left to right in picture): 50 Ω/250 Watt, 50 Ω/150 Watt, and 50 Ω/25 Watt. These do exist in different values, most common are 100 Ω and 200 Ω. These are frequently used in combiners of the amplifiers in cellphone towers.

RFP 50R/250W RFP 50R/250W RF Florida-Labs 50R/250W RF Florida-Labs v50R/350W

Regularly 150 Watt and 250 Watt 50 Ω resistors are offered on hamfests and eBay. Normally these are a ceramic disc attached to a silvered copper-mounting strip. If the resistor has one tab then this mounting strip is the other leg of the resistor. This makes it possible to make all connections coaxial and very short, thereby reducing the inductance and capacitance. The thin gold plated tab needs to be connected in such a way that it will allow for expansion when the resistor heats up.

0 - 500 MHz (500 MHz SWR < 1.3), continue 800 W on a suited heathsink (1500 W PEP short period)

Shaping it into a 'U' figure if the tab is still long enough.

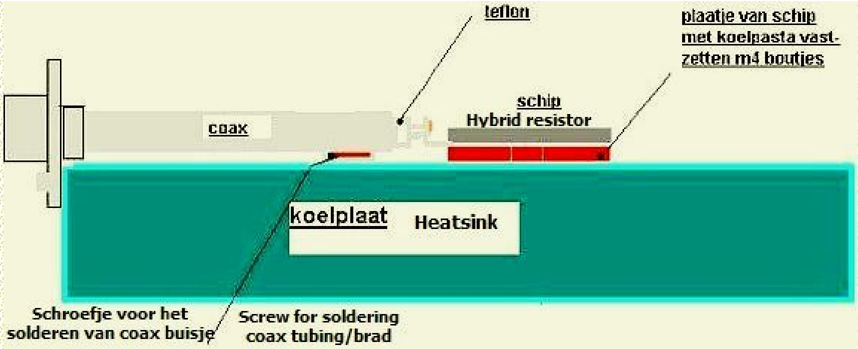
One thing to remember is that one tighten the screws on a transistor or a hybrid resistor far too much. Doing so will distort the heatsink resulting in a bad thermal connection between the heatsink and the component. Please refer to manufacturers specifications for the right torque.

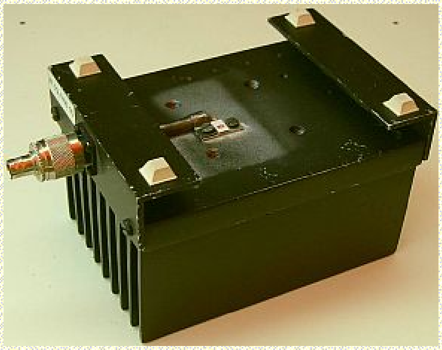
EXCESSIVE DRIVE

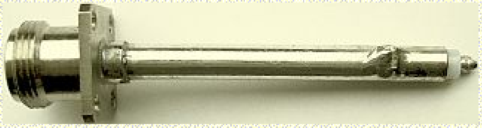
It is my experience that a stripline resistor cannot handle excessive voltages in contrast to ordinary resistors. This means that a 150-Watt resistor should not be exposed to a peak voltage that is higher than approx. 120 Volt

MOUNTING

It is interesting to discover that independently of each other a number of hams have come up with an almost the same way of making a dummy load. The picture by PA0KBT hardly needs an explanation.







Ready made system found on a hamfest.

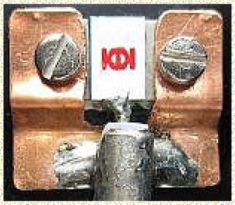
In the pictures above one can see how a 150-Watt dummy load was made. The ready made N-connector with attached coaxial connection made construction real simple. Build in this way it will go up into the GHz range.

In contrast to the drawing made by PA0KBT the hybrid resistor was mounted in a way that minimised the length of the earth connection between coax and the mounting tab of the resistor.

If using coax with a solid centre make sure that («fig) the tag on the resistor can extract/expand when heating up, otherwise it will crack the resistor. Be careful bending/handling the tab because it is breaks easy.

It is simple to make something similar to the shown N connector using some coax with Teflon (PTFE) insulation.

SWR/2m/70cm = 1.03.



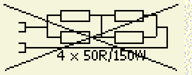
Here is another method to assemble the 150 W resistor induction free as possible. The standing wave ratio at 2 m and 70 cm were SWR/2m/70cm = 1.03. The heatsink is a smaller version than the below product, because I do not use it as a continuous load during experiments with 100 W transmitters.

COMMERCIAL PRODUCT


Cellwave's dummy load CL150 (150 W/1 GHz).

Here some photographs of a commercial 150 watt 1 GHz dummy load: the Cellwave 150 Watt CL150. It shows how the RF is prevented from leaking out and how a cover, the size of the hole through the heatsink and a Z-shaped 'cover' (fig») are maintaining a 50 Ohm impedance.

SERIAL-PARALLEL



Full size

An attempt to make a decent 600 W/50 Ω dummy load («fig) by using 4 × 50 Ω/150 Watt resistors for HF failed. Even in the HF region the mounting of the resistors on a heatsink and using insulation washers gave too high a capacitance. Perhaps a better solution was installing the resistors in parallel and uses a balun for impedance transformation.

There are resistors («fig) with two tabs and having the actual resistor isolated from the mounting tab. These are far more suitable for doing what I attempted.

Full size

WATT METER

At the left a homebrew Bird clone with build in 150 Watt (hybrid) dummy load and at the right a genuine Bird 43.

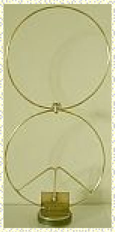
A 19-inch rack had a Bird panel wattmeter, which was cannibalised to make a wattmeter with, build in dummy load. A large part of the much heavier Bird 43 clone is heatsink and this results that with coax connections it will move a lot less on my desk. As a result I am using this wattmeter a lot and the original Bird 43 is only used for the calibration of other equipment.

«Back AØFRI

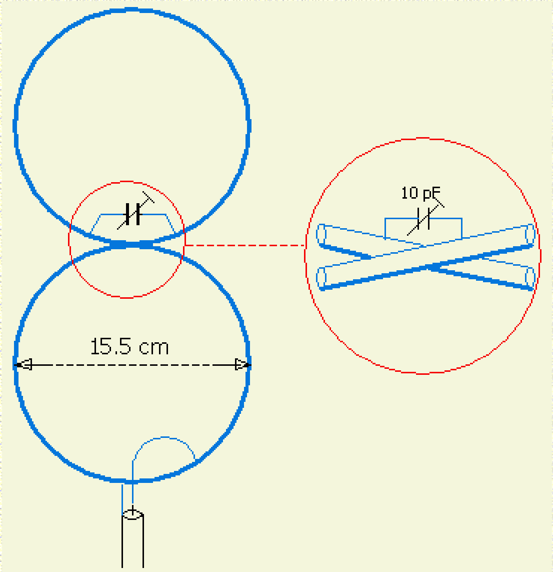
MAGNETIC LOOP "MEIGHT"

A FIGURE-8 DOUBLE LOOP ANTENNA (magnetic eight)

(MEIGHT Magnetic Eight in RSGB's RadCom May 1997)



INTRODUCTION

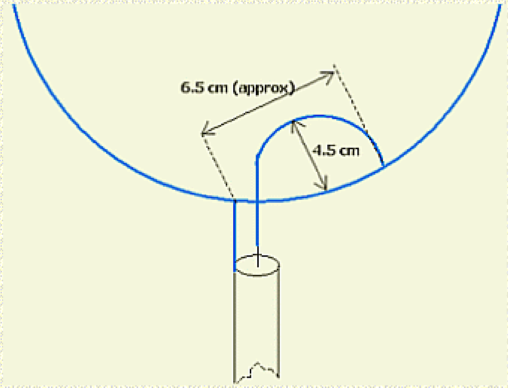


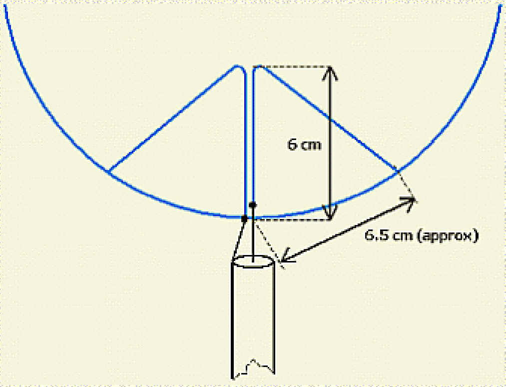
Much has been published about magnetic antennas. Their performance on the air with a loop circumference shorter than ¼ λ often belies their low theoretical efficiency. There remains the narrow bandwidth, which often requires elaborate tuning provisions.

I thought that two loops shaped as the figure-8 might bring relief and that with two paralleled loops the impedance at the tuning point might decrease and that the magnetic fields support each other. So I tried it on 145 MHz, a size very convenient for experimenting.

The figure-8 double loop shown (fig») is resonated with a piston trimmer which also mechanically separates the two conductors at the crossover.

FEEDING



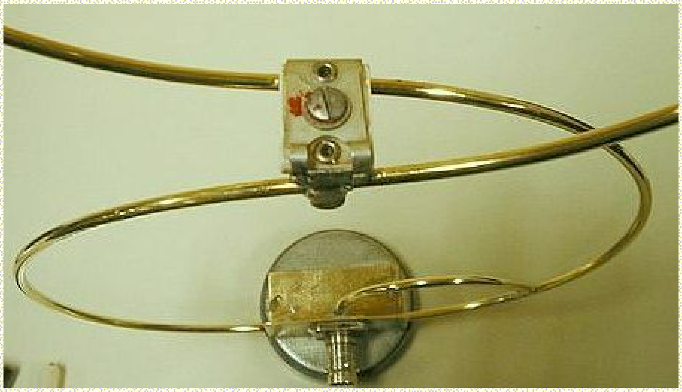


Quasi delta match.

Combimatch.

Neither the usual coupling loop or gamma match satisfied me, then the idea occurred of combining the two: it worked, and I call it Combimatch («fig). However this loads the antenna unsymmetrical so I was looking for a more symmetric system. It turns out that a delta match was the answer whereby one part is not connected to the feeder line but loads the loop similar as the other half with the connected coax cable. This feeding system, I call it "quasi delta match", perform as the combimatch but loads the loops more symmetrical.

CONSTRUCTION



The double-loop (15.5 cm diameter) was shaped from a 1 m length of 3 mm diameter brass welding rod. Using thicker copper tubing may increase the efficiency. A can with an approximate diameter of 12 cm makes a good bending jig. The loop was closed at the crossover by soldering the rod ends into a 2 cm long tube with an inner diameter of 3 mm.

The tuning capacitor is a 10 pF ceramic piston trimmer or mica stamp trimmer which were adequate at a power of 10 W. For outdoor use, some kind of weatherproof enclosure for the trimmer will be required.

One antenna is mounted on a short length of angle profile, which also carries a BNC socket. The assembly is then cemented at the feed point onto a magnetic mount for mobile use. In another version the loop is soldered onto a BNC plug for direct installation on a handheld transceiver.

The Combi-match is also made of brass rod, but only after trial with one made of soft copper wire. It turns out that the precise attachment for a point with best SWR depends on the way the BNC connector is mounted.

Generally one emphasises that the capacitor must be a high RF voltage type, but little attention is given on the large flow of RF current which can run. That appeared already with a power of 10 W, because some ceramic trimmers became considerably warm and that changes the capacitance. After polishing the brass that phenomenon was much less, a proof of large VHF current on surface of the rod. For use outside the capacitor should be protected with a housing I against protect against influences of weather.

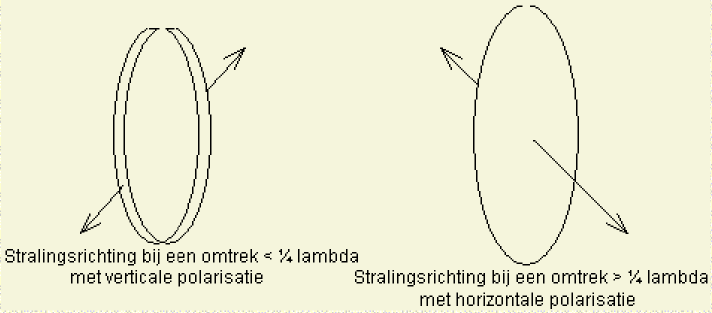
TUNING AND TESTING

Adjust the trimmer with a non-metallic tool and find the precise attachment point of the combi-match for unity SWR at the operating frequency. The 2 : 1 SWR bandwidth is around 1 MHz.

Polarisation is exactly vertical at a circumference < ¼ λ. The azimuth radiation pattern is figure-8, with very narrow nulls. Surprisingly, the nulls are not noticeable in mobile operation. In fact flutter seems to be less bothersome than with the usual ? λ or ? λ mobile whip. Note: if the circumference > ? λ the polarisation becomes horizontal!

Efforts to use a second antenna as a parasitic element to improves the gain or change the pattern were unsuccessful.

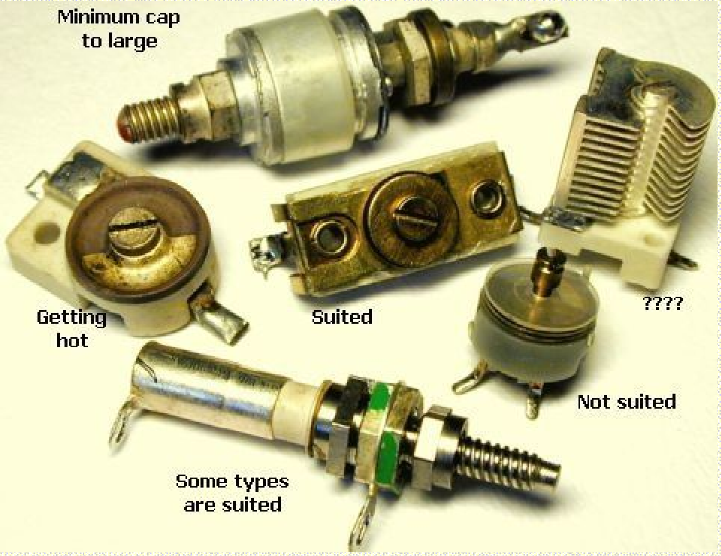
I would like to hear from anyone who has tried the figure-8 MEIGHT loop antenna on lower frequencies, e.g. 10-80 m.



Left: The radiation direction at a circumference<¼λ and vertical polarisation

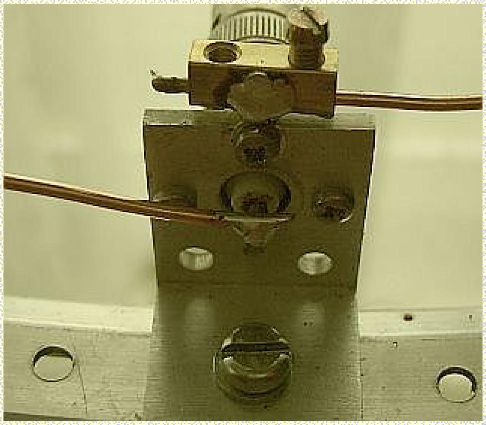
Right: The radiation direction at a circumference>¼λ and horizontal polarisation

CAPACITORS

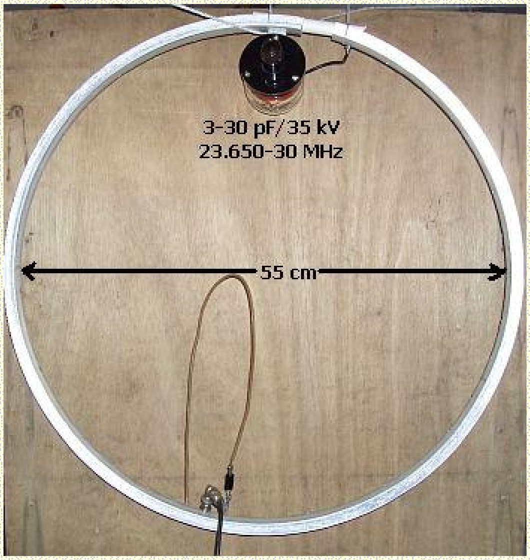


TEST A LOOP FOR HF

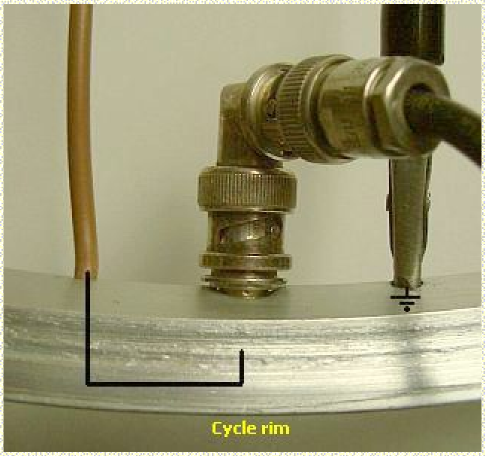

I used an aluminium cycle wheel for the loop. With a 16 - 150 pF cap the range was 11 - 30 MHz.

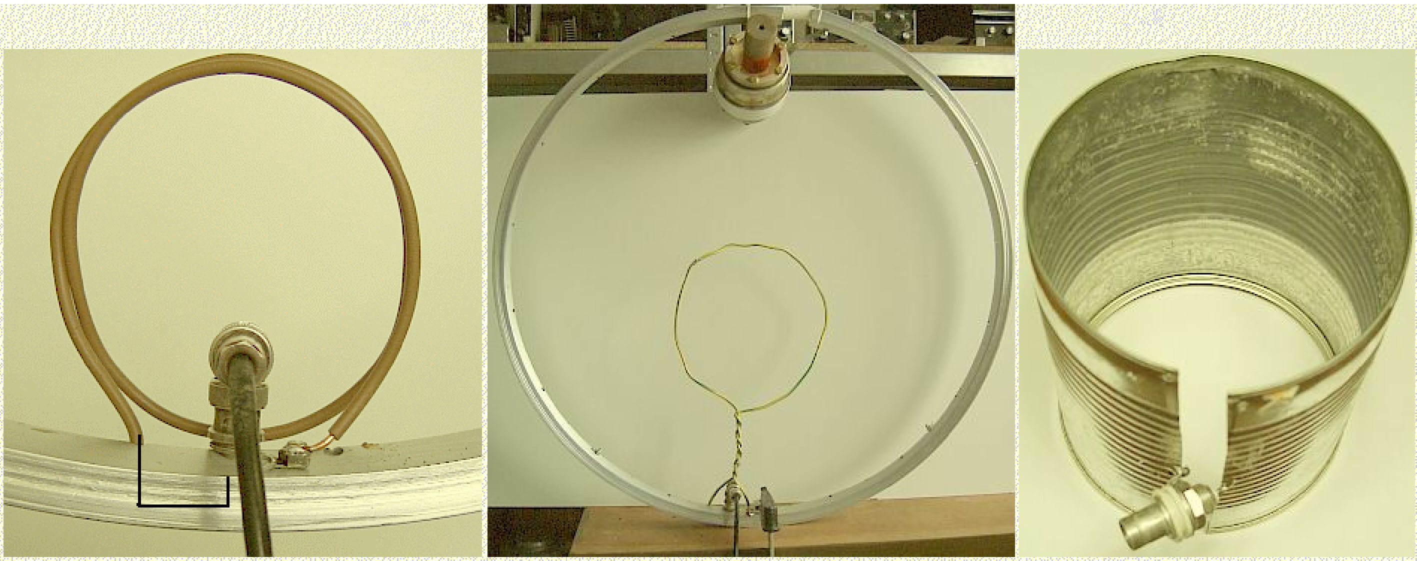
Matching the coupling.



With a 100 pf cap the range was 10 - 14 MHz.



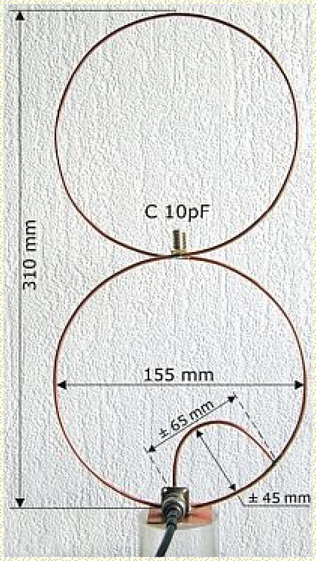
Hairpin coupling

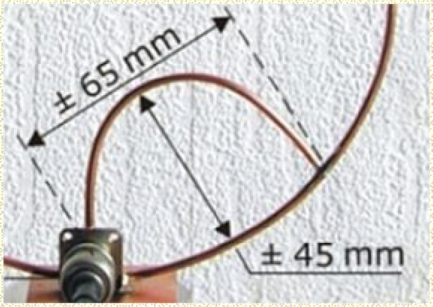


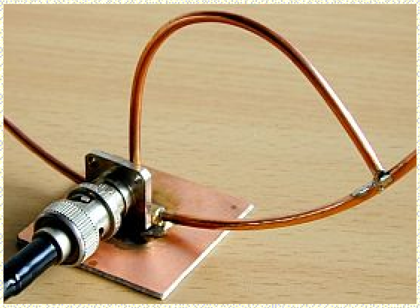
Coupling with 2 turns of 8 cm diameter, 1 turn of 12 cm diameter or with a tin-can.

PA1AMS's test with a "CD" sized 145 MHz loop.

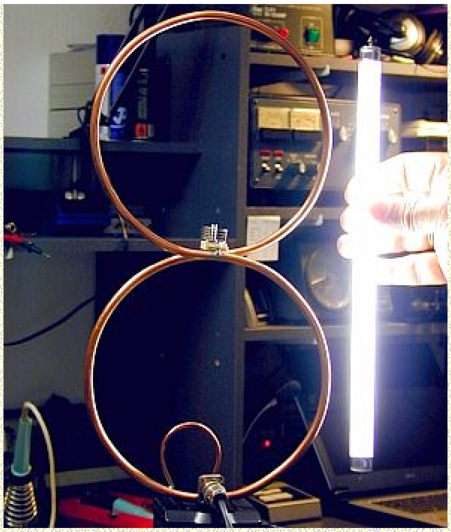
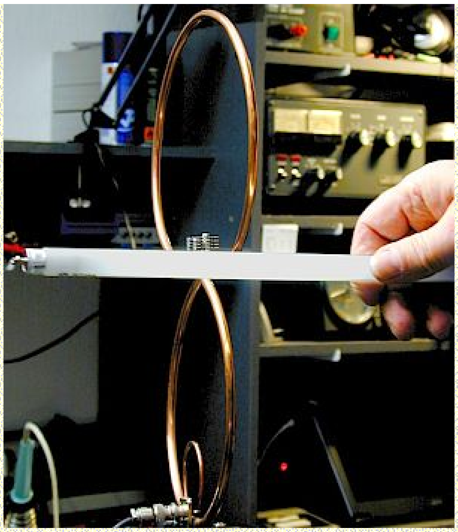
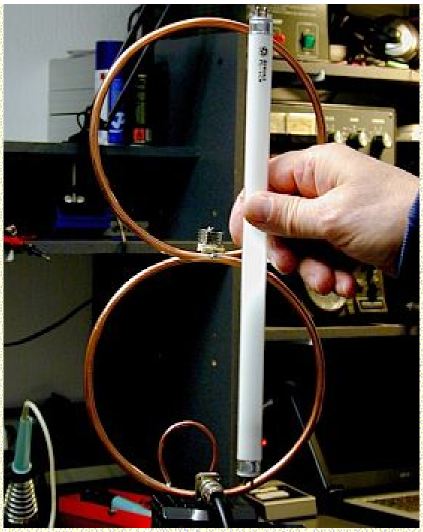
PA9OK's (SK) EXPERIMENTS



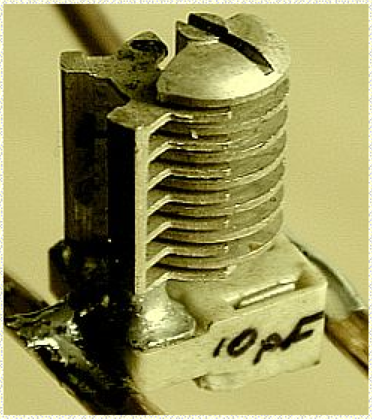


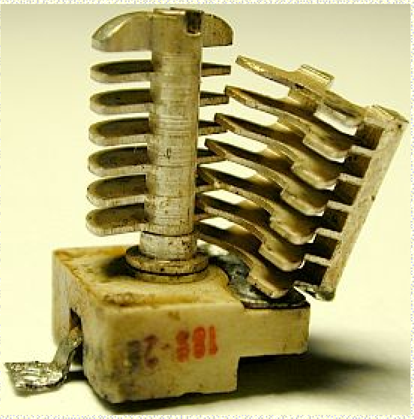


Radiation pattern

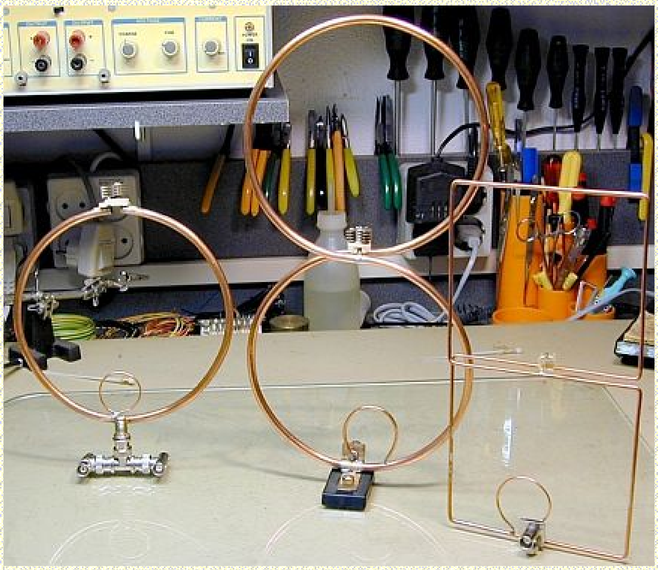
Vertical polarization (tx = 10 W). **Minimum horizontal polarization.** **Zero horizontal polarisation.**





The result of the VHF current.

A home made capacitor with Delrin insulation was getting hot.

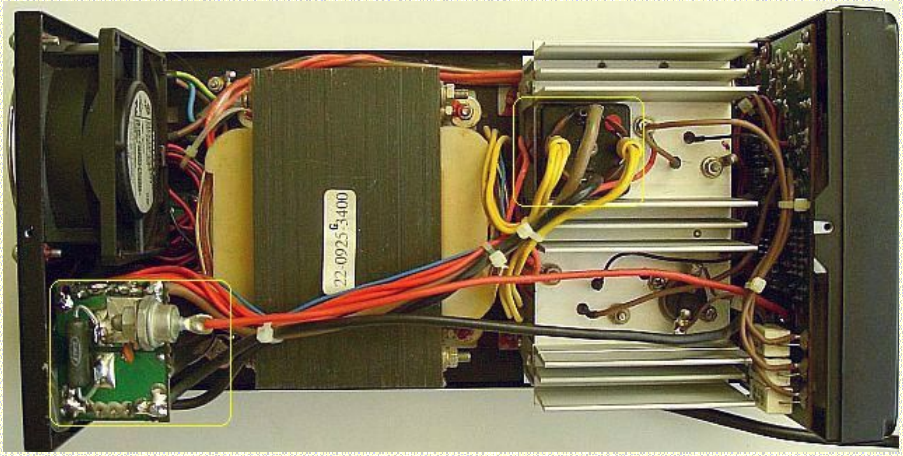
The tested loops.

«Back AØFR

MANSON EP-925 MODIFICATIONS

Also Conrad, Daiwa, ITG, Palstar, Stabo, Velleman, Voltcraft power supply.

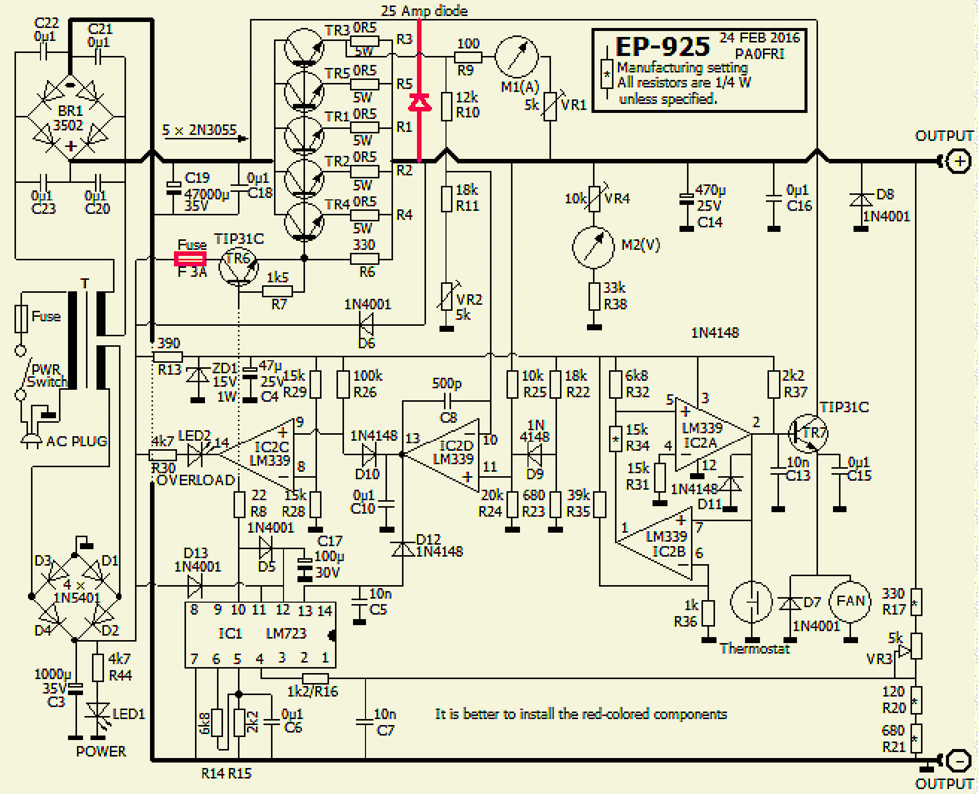
18-jul-2016 The resitor in TR7's collector is not always installed!



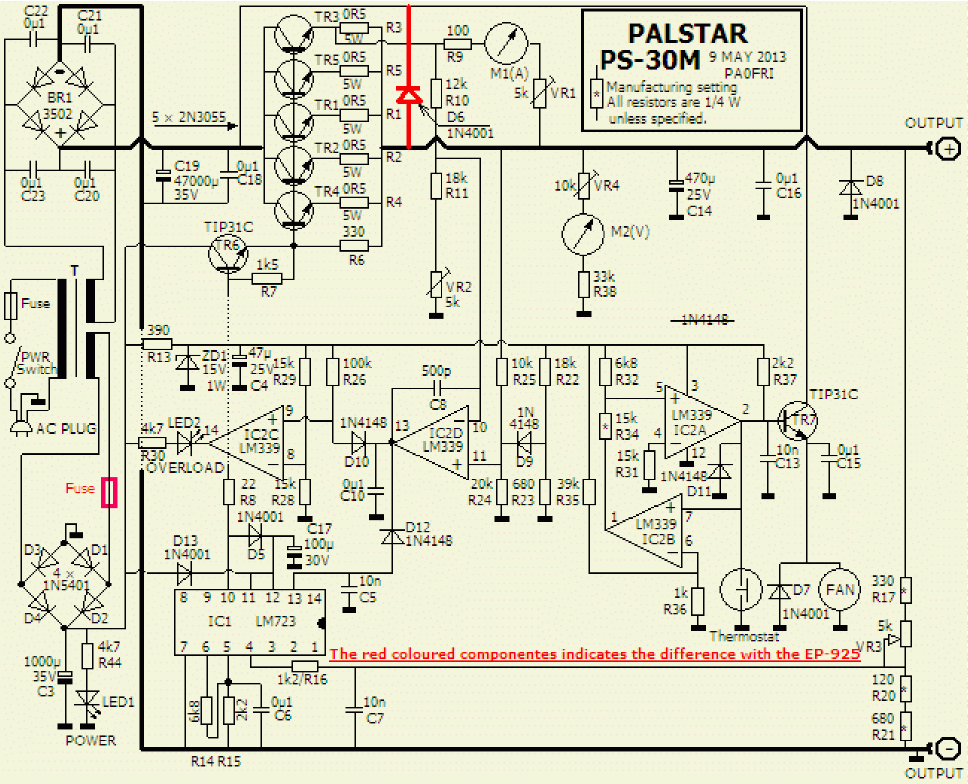
EP-925 and PALSTAR PS-30M

On the Internet circulates an unclear copy of this supply's diagram and one is regularly asked for a better drawing. As owner of this device I also wanted a good readable diagram. So I draw a compact one using the Internet's example but it turned out the example had a lot of errors. Therefore it was again drawn according to a MANSON ENGINE RING INDUSTRIAL LTD's Jun 99 redrawn schematic (tnx PAØKV).

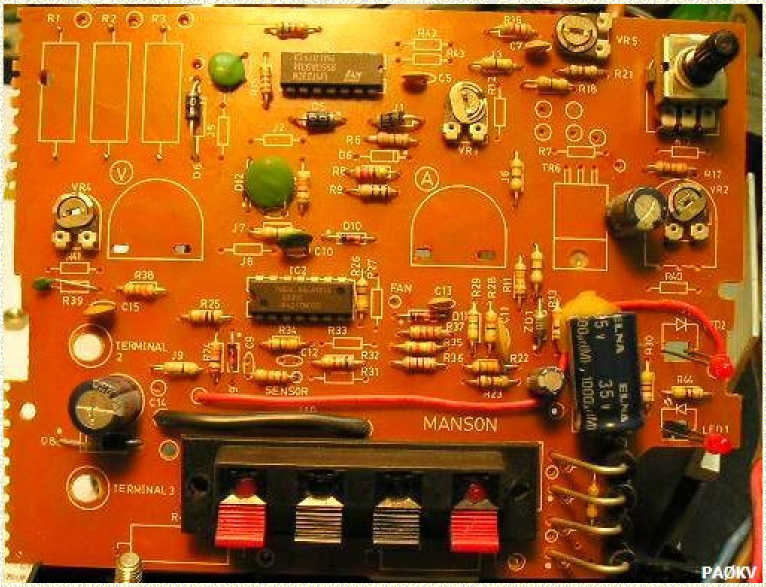
Click on Manson for more types of Single Output DC regulated power supply.



The Palstar below is almost similar except two red coloured components.



SHORTCOMINGS



This power supply («fig) is also for sale as EP-925 by Conrad, Daiwa, ITM, Manson, Palstar, Stabo, Velleman, Voltcraft and others. The unit is used in many shacks but it has some shortcomings, which have resulted in failures. Fortunately the device can be improved by some modifications.

OVERVOLTAGE

Remember that a surge protector is not present. If one transistors (TR1-TR5) blows, the entire unregulated voltage (~ 24V) is connected to your set and it will usually not survive. Such protection is still not in my EP-925 installed. You know the routine, the plan exists but it need not be directly because I have other power supplies available. When use the EP-95 with a transceiver I always connect a small battery in parallel.

At right (fig.1») is the principle of a (15 V) overvoltage protection system. It is almost a standard "brute force" circuit with a Zener diode driving a thyristor, which short-circuit the overvoltage, a fuse blew and the set is no longer energised. Details of such security can be found on the Internet.

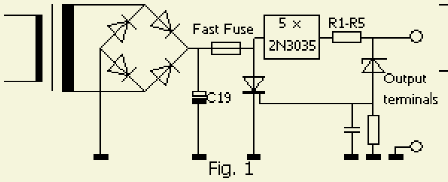


Fig. 1

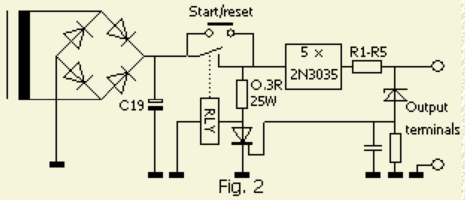
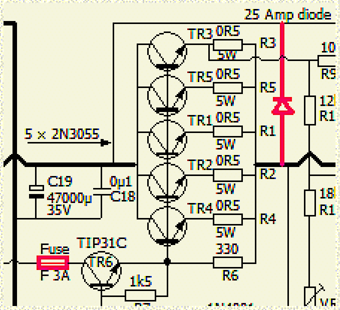


Fig. 2

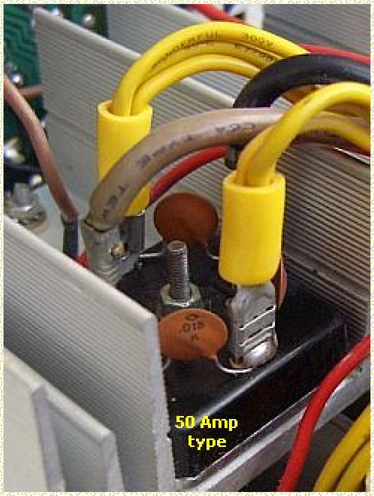


A less crude system (fig.2) is very similar. After turning the main switch and press the start/reset button, the relay connects and the power supply is on. If the voltage at the terminals is too high, the thyristor is conducting and the voltage is reduced to a safe value by the large current through the 0.3 Ohm resistor. Simultaneously, the voltage across the relay is almost zero and disconnects the load. This is not a brute force system and the thyristor is less affected.

G3MWO wrote me: "With the crowbar applied, then there is a path from the auxillary smaller power supply up through the TIP31C (TR6) and back through the combined path through the base/collector junctions of all the 2N3055 transistors in parallel" (or via the extra diode #PAØFRI)

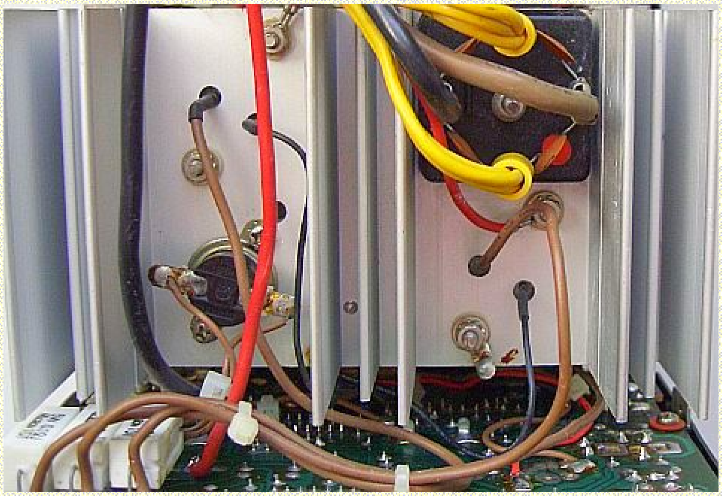
In order to protect TR6 install a 3 Amp fast fuse in series with TR6's collector.

BRIDGE RECTIFIER



In my EP-925 only a 20 amperes bridge rectifier (DR1) was mounted, but the factory fitted also a 25 Amp type.

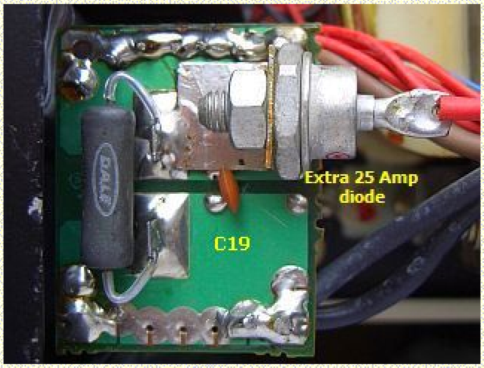
Both rectifiers are only suitable for continuous use with about 12 A or 15 A and not to the specifications of a 25 A continuous current or 30 A peak current. One has experienced that a sustained large current will develop a fault.



I did not believe the factories specifications and therefore I tested the supply thoroughly. The rectifier collapsed, but that was partly due to lack of cooling. The cause: the mounting screw and nut were lose and there was no thermal paste applied between bridge rectifier and heat sink. It is advisable to check all the fixing and thermal paste because my transistors were providing with almost nil paste. After a 50 A rectifier bridge was installed the power supply specifications were right and the unit has not failed since 1994.

SERIE TRANSISTOR

During the mentioned test a 2N3055-power transistor had gone short circuit also by lose fixing and nil paste. Again, check your power supply for essential fixings and sufficient thermal paste.

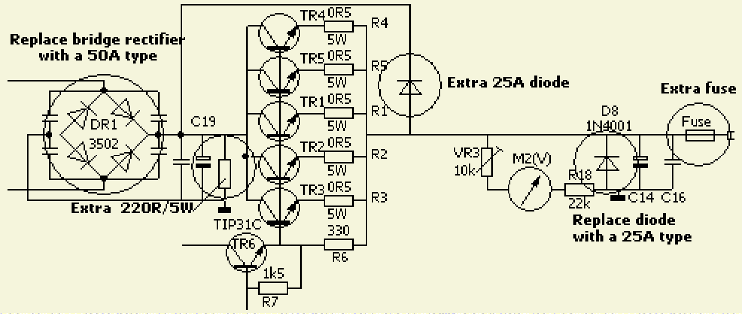


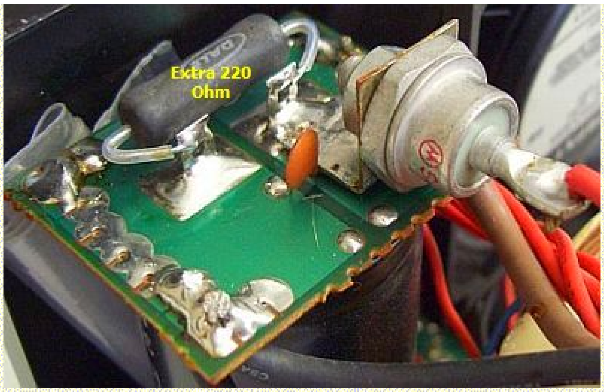
VOLTAGE REMAINS

When the power is switched off, the voltage remains for some time. For a faster discharge a load resistor (fig») was installed parallel to the unregulated voltage across capacitor (C19).

EXTRA DIODE

If the supply is used for battery charging it may happen that the power is switched off before the battery is removed or the battery is connected before the unit is on. Temporarily components can have a reverse polarity and failure. A large diode (fig») mounted from the positive terminal to the plus pole of C19 can avoid this.

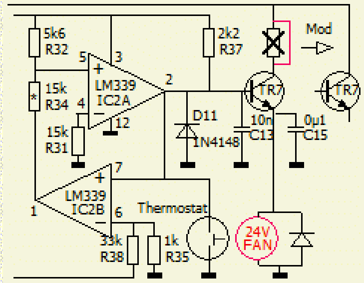




DIODE EN EXTRA FUSE

If accidentally the poles of a battery are reversed, diode D8 (1N4001) conducts and not survives. One can installed the known reverse protection circuit by replacing a stronger diode type (> 20A) and an additional output (25A) fuse. In case of wrong connection the diode conducts and the fuse blow.

OTHER FAN

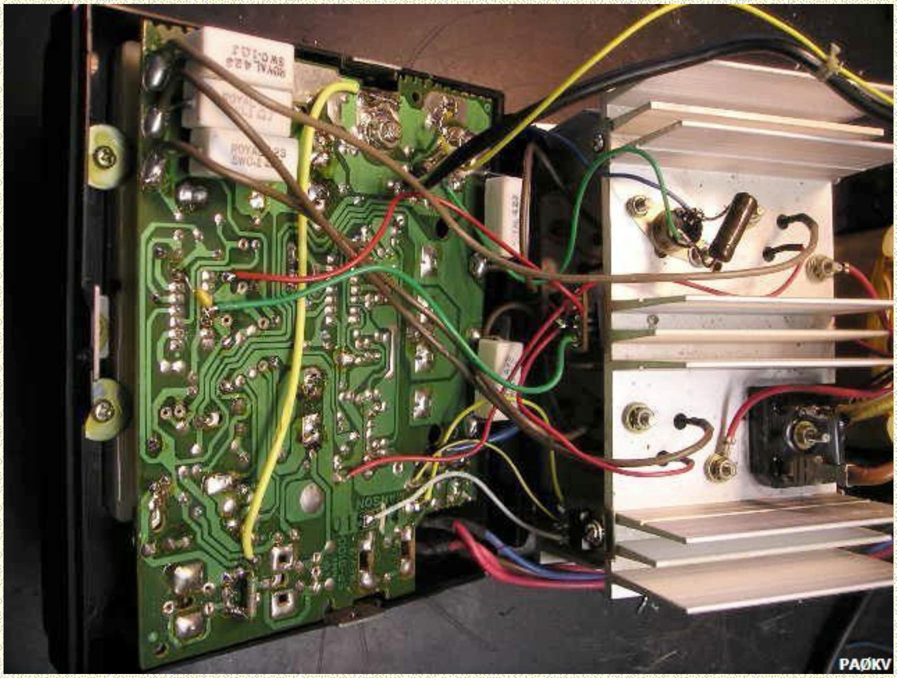


The original 12 V fan was too noisy and did not sufficiently cooled at maximum load. That is mainly because the insufficient mounting of all components. One resistor («fig) was removed or short circuit and a powerful fan type was replaced: a 24 V PAPST Multifan 8314. Now the airflow is sufficient with less noise.

The resistor in TR7's collector is not always installed in this type of power supply!

G3MWO cured the overheating by running the fan slowly all the time - but also added a series of 6 mm holes in the bottom of the case just in front of the heatsinks for air flow through the lower heatsinks.

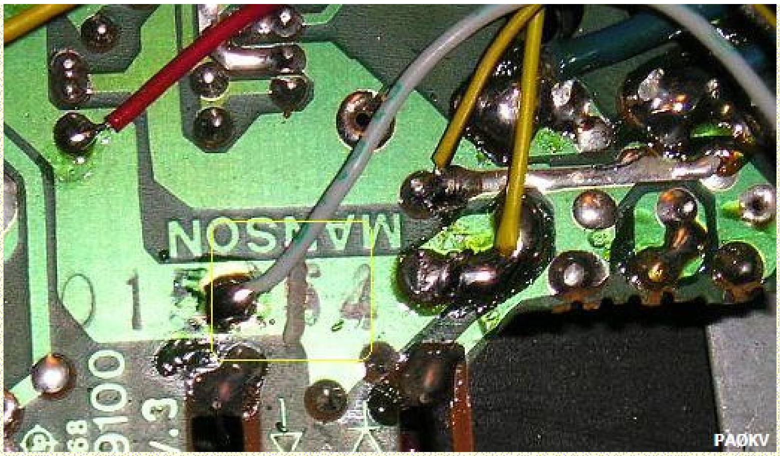
PAØKV's MODIFICATIONS



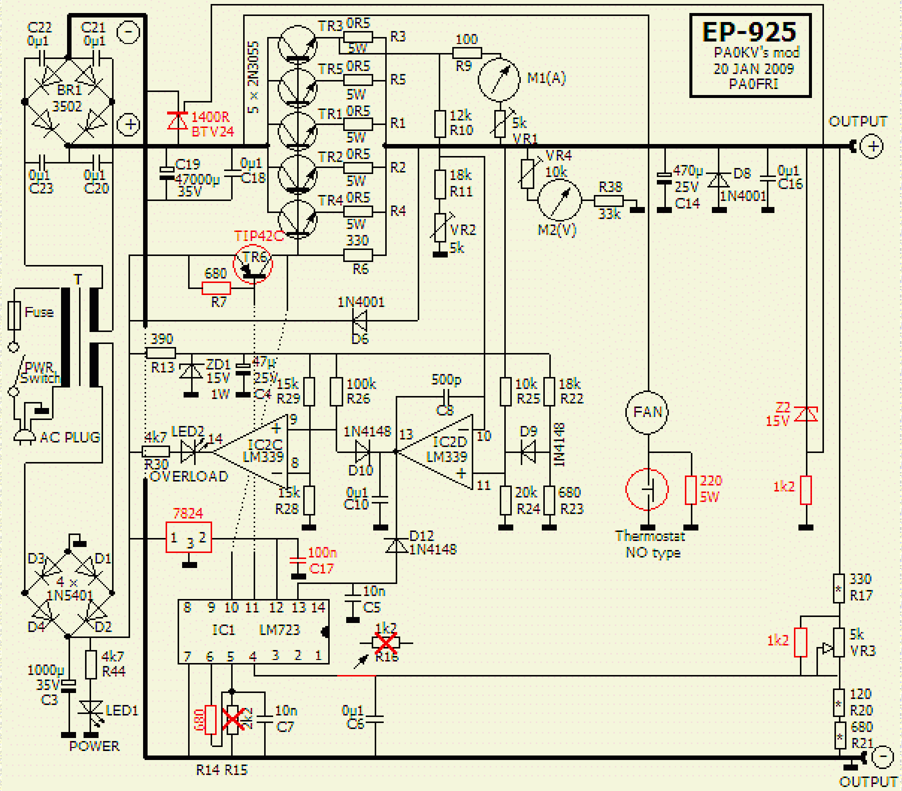
PAØKV has designed some interesting changes. He was not satisfied with the voltage stabilization at maximum load. In examining the cause he discovered a number of weaknesses of the design. In his enthusiasm to proceed, he thought the changes might be too far. However the result was a safe, quiet and stable 13.8 V supply for its transceiver. His findings are given below

STABILITY

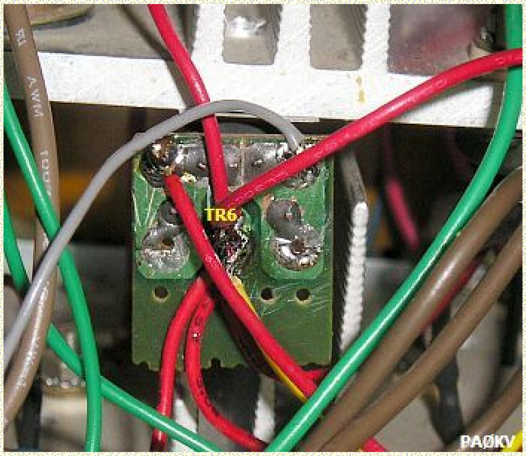
The LM723 (IC1) voltage regulator is not working properly despite feeding with a separate winding on the transformer. The output voltage varies considerably due to the heavy load of the system to the other secondary winding and probably by thin wire on the primary windings.



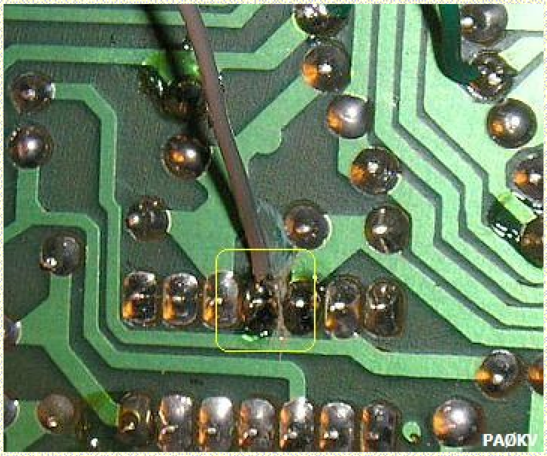
To improve, he replaced D13 (1N4001) with an additional 24 V stabilizer (7824) mounted on the heat sink and a track was interrupted. Since C17 was not installed in his EP-925 he mounted a 100 nF capacitor.



The changes are marked in red. The circuit for the fan is simplified.

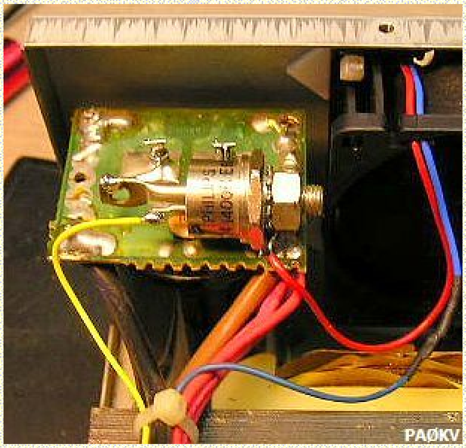


The circuit of the LM723 (IC1) voltage regulator could be improved. NPN TR6 (TIP31C) was replaced by a PNP transistor TIP42C with increased HFE that contribute to the stabilization. A track (fig») below IC1 was cutted. Further pin 12 (V^+) was connected to 7824, pin 11 (Vc) to the base of TIP42C, pin 10 (Vout) to the emitter of TIP42C. Resistor R7 (1.8 k) replaced by 680 ohms and R8 (22 Ohm) and D5 (1N4001) removed.



The inputs of the LM723 were designed for lower voltages (up to 9 V) to the outputs. He chose for 13.8 V, R14 was reduced to 680 ohms. He decreased the maximum voltage across VR3 (5 kOhm) to 14 V with a 1.2 kOhm resistor in parallel of VR3.

SAFE OVERVOLTAGE



For maximum 14 V voltage at the output terminal he applied a 16 V overvoltage protection. A thyristor (BTV24/1400R) was mounted in parallel with (fig») an installed bridge rectifier (50 A/120 V). A zener diode (ZD2) and resistor (100 ohms) across the output trigger the action.

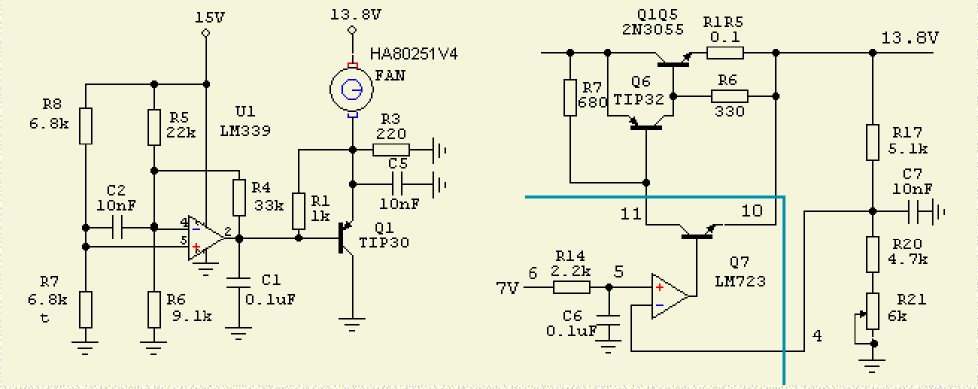
FAN

In his opinion the circuit for the fan is overly complicated: a thermostat, two opamps and a transistor to switch a fan! I am agreeing! The reason is probably the use of an NC (Normal Closed) thermostat.

The fan was replaced by a PAPST 844414NG and mounted to suck the hot air out of the casing. Thus reduces noise considerably. To increase the airflow through the side slits, he sealed the air gaps («fig) of the lid with tape.

The original fan's supply system was superfluously because the thermostat was replaced by an N-type (Normal Open) in series with the fan. With a (fig») 220 Ohm/5 W resistor parallel to the thermostat the fan runs quietly at half speed and constantly cooled the heat sinks. It's never happened that the fan was running at full capacity.

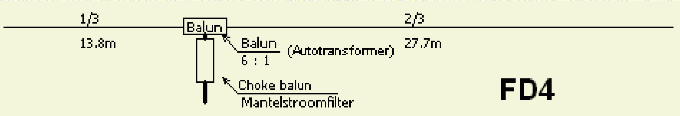
LY3BG MODIFICATIONS



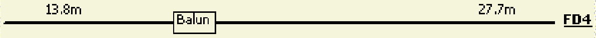
Left: R7 (6k8) is a thermistor, FAN = silent fan; Right: R1-R5 = 0.1 Ohm.

THE OCF FD4 (FD3) WINDOM ANTENNA

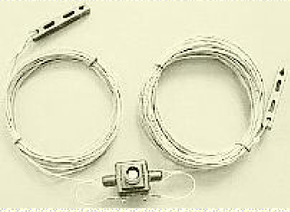
19 may 2011



FD4 (80/40/20/10 m)

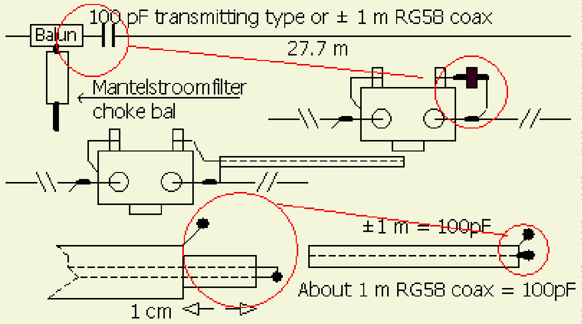


The 4-band Fritzel model FD4 is a special version of a Windom antenna. It is a half-wave long on the lowest frequency, and is fed from a coax cable through a transformer inserted in the wire at one-third from one end. Fritzel used the shown dimensions of 13.8-m and 27.7-m in the 1960s.



A 1 ÷ 6 auto transformer matched the antenna to the 60-Ω coax then commonly used in Germany. For 50-Ω coax a 1 ÷ 7 ratio would be a better choice. The Fritzel series 70 transformer (fig») has, on the antenna side, an impedance of 100-µH, approx. 2200-Ω at 3.5-MHz, i.e. more than 5 times the antenna impedance at that frequency; an excellent value.

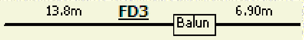
It so happened that I was then experimenting with the same system of antenna and trying to determine the best dimensions. Copying the dimensions shown above gave good results and saved me much pruning and reinstalling. On 3.5-MHz, however, the SWR was high.



Not surprising, as the antenna length was more than a half wave. I found that a 100-pF capacitor between the longer wire and the transformer brought the 3.5-MHz SWR down and barely affected the other bands. The capacitor is a transmitter type or about 1-m RG58 coax cable. Remove 1-cm of the braid on both ends and butter it with transparent contact adhesive and reassembled with heath shrink tubing. The process with the transparent adhesive is for preventing that water gets inside the cable.

Examples of capacitors used in amplifiers and transmitters.

FD3 (40/20/15 m)



The Fritzel FD3 is a half-size version of the FD4, which resonates on 40, 20 and 10-m. 15-m, can be added as described below.

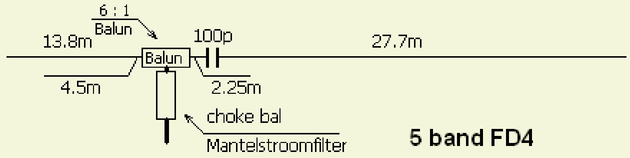
SWR

The SWR data for 80, 40, 20 and 10-m, supplied by the manufacturer, are correct only if the antenna is installed in a straight line. The proximity of conducting surfaces or structures can be detrimental to the SWR. Low height above earth, nearness to large conducting surfaces or installation as an inverted-V may shift the resonance frequency on one or more bands.

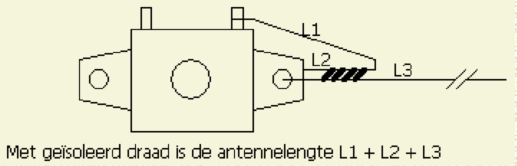
IMPEDANCE

Most Dutch amateurs cannot hang their antennas very high and that affects the feed point impedance. For an FD4 under those circumstances, 340 – 360-Ω for the resistive part of that impedance is a reasonable assumption. Some amateurs then assume that, with the appropriate transformer ratio, the transmitter sees the proper 50-Ω load but this is seldom true. The coax works as an impedance transformer, sometimes producing unfavourable impedance at the transmitter end. That is why specific lengths of cable are frequently recommended. I always use 27.2-m of 50-Ω coax with a velocity factor of 0.66: RG213 or RG58.

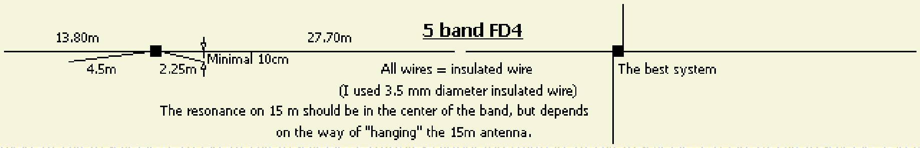
5-BAND FD4 (80/40/20/15/10-m)



Hang a 21-MHz Windom («fig) parallel to the FD4, as show, to cover 15-m as well.



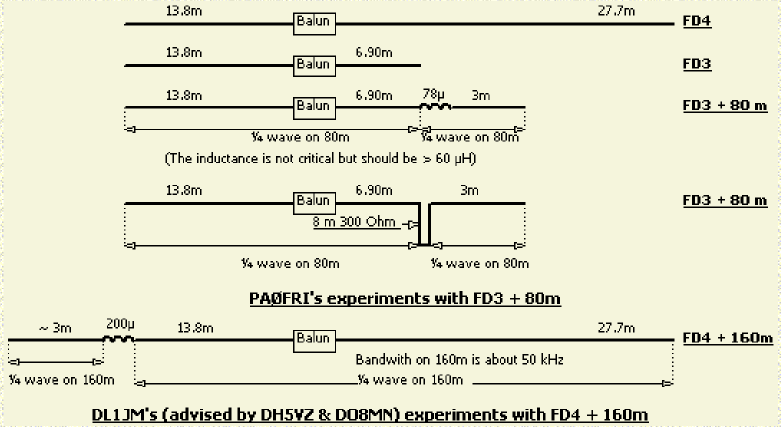
If you (fig ») used insulated wire for the antenna the reduction factor is about 90%. The calculated electrical length of an antenna leg is L= (L1+ L2+ L3) × 0.9! The beginning of the wire (L1) goes through the suspension hole, then back to the main wire (L3) and then to the connecting terminal of the balun.

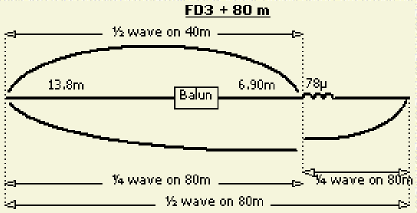


If possible hang the 15-m band antenna at right angles to the FD4.

I had no room for the extra wire and it was hung under the main antenna. It worked satisfactory both at home and in Lebanon.

FD3 (+ 80m) & FD4 (+160m)

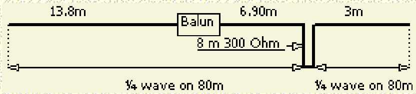




Because the limited spaces in my back garden I was forced to decrease the length of a FD4. So I did experiments with a FD3 for an added 80-m range, see the schematic.

I can not exactly remember the length between the 78-µH coil and the far end of the dipole, but start with a 4 m long wire and check the resonance and then cut the wire for your favourite frequency. However, much depends on local conditions such as height and metal objects in the vicinity. The bandwidth at 80-m is narrow comparable with a whip on an automobile. If you are matching with a tuner, the antenna can be used over a wider range.

At my request SMØFLY calculated the 3-m & 78-µH extension with an antenna program. The resonance of the antenna at about 15-m height was close to 3.7 MHz.

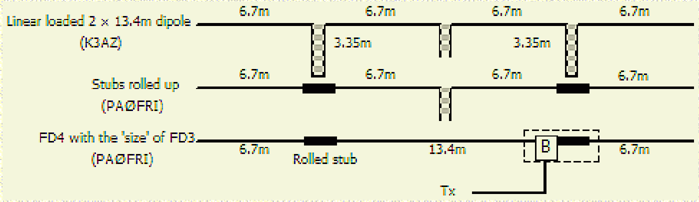


More bandwidth can be obtained with the rolled up ribbon stub system («fig).

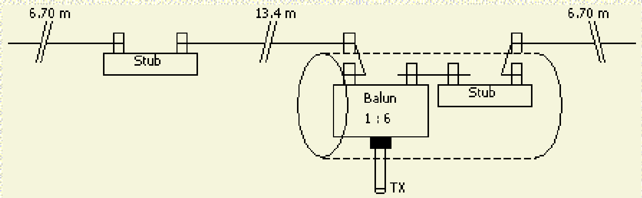
DL1JM did likewise experiments with a FD4 converted to a 160-m range, see:

http://www.mods-ham.com/02_Mods/Other-Mods/FD4-Umbau/FD4_Umbau-Erweiterung.htm

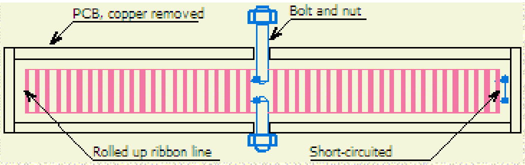
SHORTED FD4 (a modified K3AZ antenna)



The modified K3AZ antenna becomes a FD3 sized FD4 with a 6 ÷ 1 or 4 ÷ 1 balun. The SWR on all bands will not be as good as an original FD 4, but with a built-in or external tuner you can use this antenna. I had that system for about 4 years. Suitable ATU's are for example my [Fri-Match](), a two-button system for 10 to 80-m or any other asymmetric tuner such as T-match, LC loop, Pi-filter, etc. One advantage is that the rolled-up stub and balun (fig») can be constructed in one enclosure as an insulator.

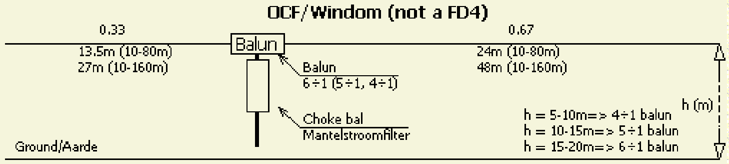


Ribbon line.



Stub made with Rolled up ribbon line.

OCF/WINDOM



Fritzel with his FD4 design has others encouraged to produce or experiment with off centre feed (OCF) antennas. Currently, there are a lot of such types under many names listed. These OFC's have been other dimensions and are often suitable for some WARC bands. The feed point is at 33% of antenna length.

The height above ground will affect the feed point impedance and the transformation ratio of the balun. The lower the antenna the lower the impedance of the feed point. A rule of thumb is (fig»):

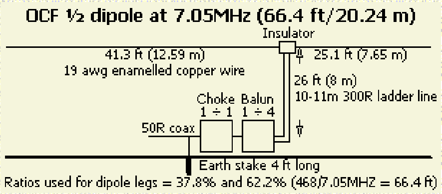
height 5 - 10-m » 4 ÷ 1 balun

height 10 - 15-m » 5 ÷ 1 balun

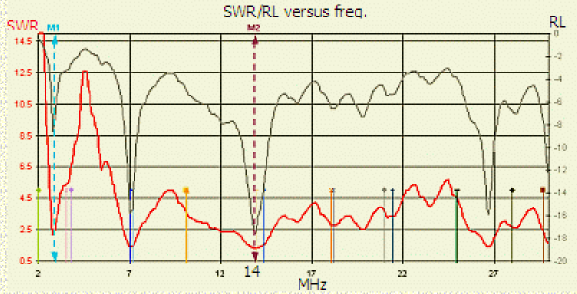
height >15 - 20-m » 6 ÷ 1 balun

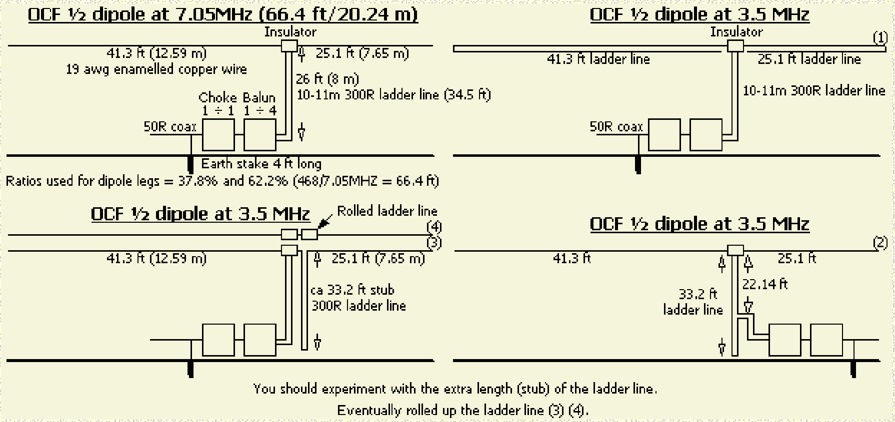
If you want to experiment then takes account of these data.

2EØZEH has built a 40-m OCF dipole and would like to add an extension for 80-m. Here are a few possibilities for an 80-m antenna in the limited space. It is necessary to experiment for the length of the ladder line.



2E0ZEH's version of an OCF.



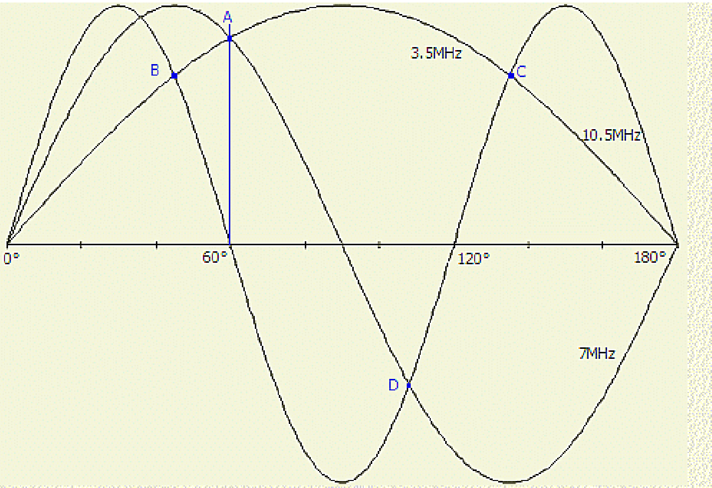


Some of my not tested ideas to extend this 40-m OCF with 80-m.

MORE BANDS

It is shown that FD3 and FD4 have resonances in the WARC bands, but I have no practical experience because I had no equipment for 160 m and the WARC bands at the time of my experiments. At point A (the"Window"point) of the graph (fig») you can see that the antenna on 40 and 80-m have equal impedance. It is not drawn but the same point also applies to the 10 and 20-m band. That means that at the one feed point the antenna is suitable for 10, 20, 40 and 80-m.

Such reasoning applies to points B and C for 30 and 80-m and point D for 80-m and 30-m. Apparently by choosing on a clever way the length of both wires the antenna ca be used for more than 4 bands.

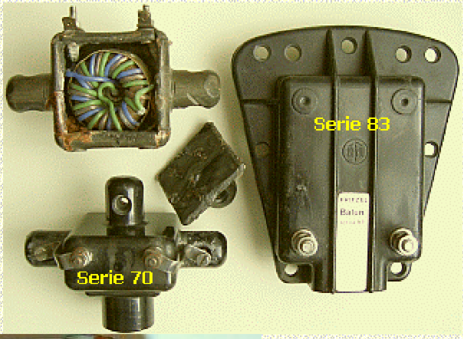


LA1TNA claims for FD4 an SWR of (fig »):

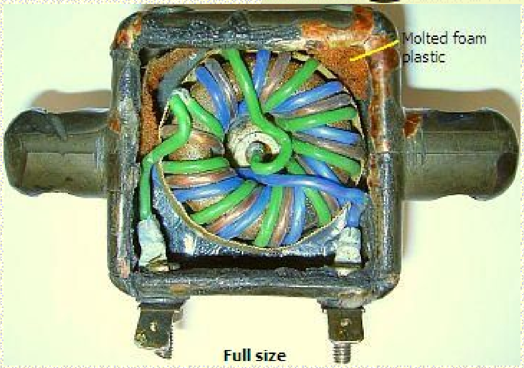
80-m SWR = 1.7	**20-m SWR = 1.5**	**12-m SWR = 1.5**
40-m SWR = 1.3	**17-m SWR = 1.3**	**10-m SWR = 1.3**

The antenna is also suitable for 160 m if you replace the 13.5-m leg of a FD4 by a length of 54-m. The total length is therefore 27.7 + 54 = 81.7-m!

LF DETECTION THROUGH THE TRANSFORMER

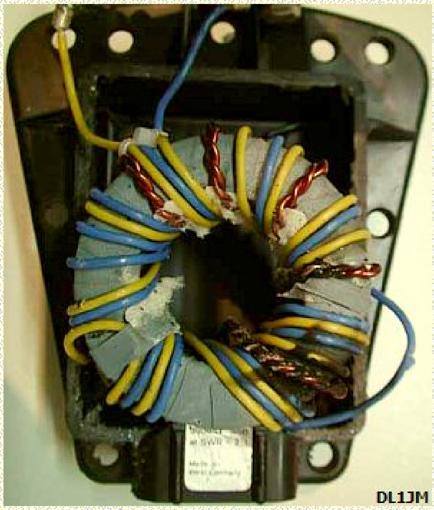


At the time I was given a (low power) Fritzel series 70 6 ÷ 1 'balun', damaged by its owner who had applied 400-W on 21-MHz to it. The case had been cracked open («fig) and had partly molten, but the contents were OK. I found that the so-called 'balun' was not a balun at all but an auto transformer, with a direct connection between the outer of the feeder and one of the two antenna wires.

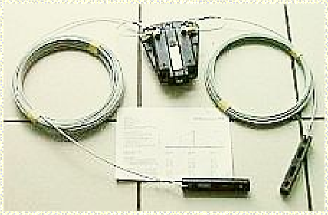


That explained why many amateurs with an old model Fritzel 'balun' were bothered by LF (coming from the radiation of the coax cable) detection in their own or their neighbour's equipment. I advised them to install a choke balun near the auto transformer consisting of eight turns of the coax wound through a green Philips 3E1 toroid, which fixed the problem; see also 'feeder radiation', below.

For my own experiments I used a true 4 ÷ 1 balun in the antenna and, below it, a 1.5 ÷ 1 or 1.7 ÷ 1 auto transformer for a match to a 50-Ω coax and did not experience that problem.



An autotransformer and choke balun were fitted in the case (insulator fig») of the series 83 balun so that the unwanted current on the braid is suppressed and reduces interference in other apparatus. It's not wise to load an original FD4 with high power on the 15-m band.



DL1JM sent a photo of an overloaded Fritzel series 83 1 ÷ 6 balun. It was damaged by flashover, a result of too much power and the intrusion of dust and dirt on the twisted copper wires. You can clearly see the two black spots in the picture. He repaired and improved the balun with Teflon insulated wire, removed the 1 ÷ 1 (choke)balun and replaced it by a W2DU type. The latter consists of 25 ferrite toroids on the coaxial cable close to the feedpoint. (See an example below) The renewed balun now works perfectly with high power in combination with a FD4 + 160-m extension, see up in this article.

FEEDER RADIATION

Experimentation with the original Fritzel transformer has shown that the antenna can function as an inverted-L if the feeder does not run at right angles to the antenna. The part of the antenna nearest

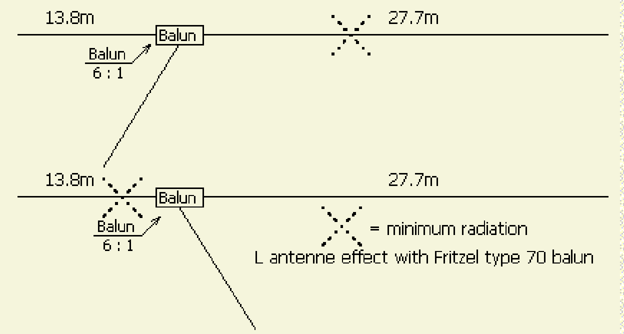
to the feeder radiates most and operates like an inverted-L with the outer of the coax.

A choke balun between the transformer and the feeder prevents this. 3 – 4-m of RG58 coax wound on a former of 7 – 10-cm diameters will do and can handle 400-W.

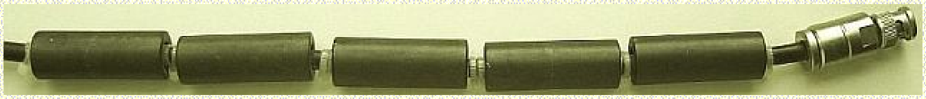
Obviously, Fritzel have discovered that too. Since 1980, the housing and power capacity of their series 83 contains not only the 6 ÷ 1 (fig») transformer but also a choke balun; the strain insulators have also been changed.

Still it is better to route the coaxial cable line to the shack by running it at least 5 m to the ground and then at a 90° degree away from the antenna.

Choke baluns.

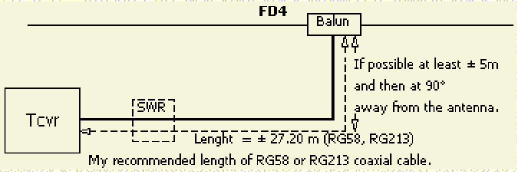


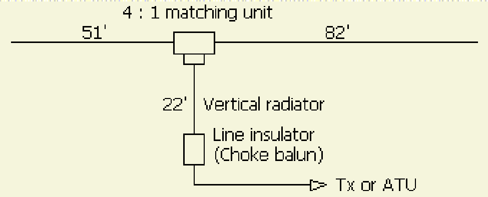
Balun: left serie 70, right serie 83.



Choke balun.

With an eventually extra choke balun the 3 – 4-m coax used for the balun becomes a part of the recommended 27.2-m length (fig»).

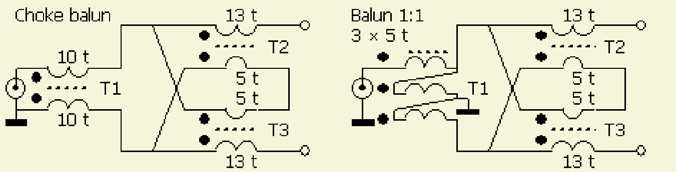




Some Windom-derived antennas enhance feeder radiation on purpose. One example is the Carolina Windom (USA) which provides both, horizontally and vertically polarised radiation.

An FD4 is often be titled as being a dummy-load, but that is mostly hearsay or because one of the side effects have occurred. If proper matching and suppression of feeder radiation are taken care of, this antenna works as effectively as any other radiator of the same length and location.

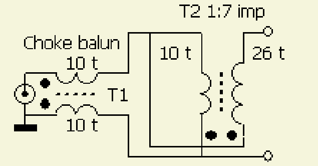
MATCHING (1)



Windom (FD4) 1 : 7 Matching Unit with 3 × 4C65 (purple) ferrite toroid, T1, T2, T3.

Matching a 50-Ω cable to an FD4 requires a balun and an impedance transformation of 1 × 7 (1 × 6.7) On the feeder side there is a choice between a choke balun and a trifilar 1 × 1 balun. Two violet Philips 4C65 toroids, T2 and T3, are required to make the 1 × 7 balanced impedance transformer.

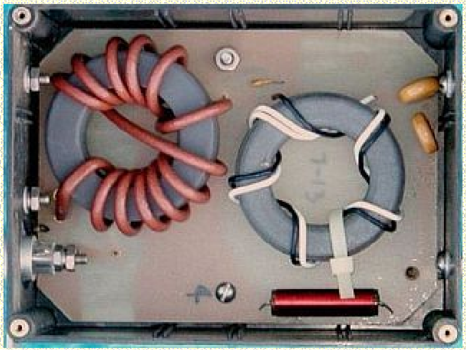
MATCHING (2)



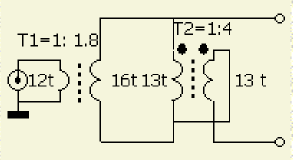
Matching with 2× 4C65 toroid, T1, T2.

It can also be done with only two cores but then it is difficult to get all the windings of suitably insulated wire onto T2, which then also can handle less power.

It should be possible to do it with thin insulated wire as shown in the right-hand photograph. It shows, here only as an example, the balun system of a Cushcraft R5 antenna. The bifilar 10-turn coils are placed over the centre of the 16-turn winding. Use wire with good insulation. In the photograph, the brown coax on the left core and the wire on the right core are Teflon insulated.

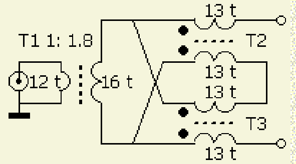


MATCHING (3)



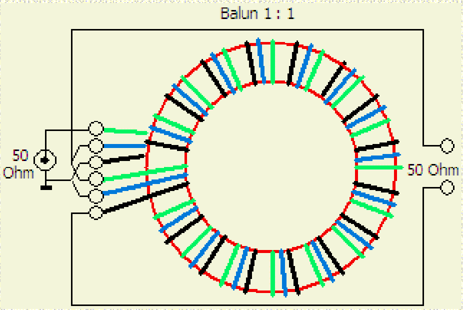
1 : 7.2 Matching Unit with 2× 4C65 toroid, T1, T2.

An insulation transformer T1 with an impedance ratio of 1 ÷ 1.8 (1 ÷ 1.78) raises the impedance level from unbalanced 50 Ω to a reasonably balanced 90-Ω. Thereafter, T2 (T3), a 1 X 4 'balun' connected as a balanced transformer, raises that to 360-Ω. I prefer this feed system because there is no galvanic connection between coax and antenna, minimising the danger of RF on the coax outside.

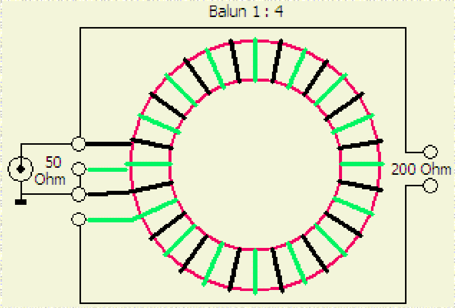


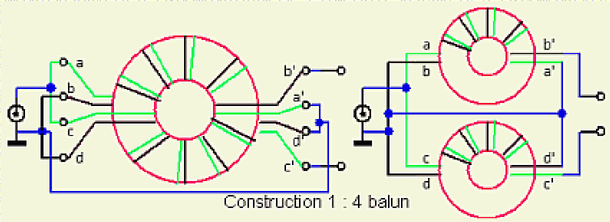
1 : 7.2 Matching Unit with 3 × 4C65 toroid, T1, T2, T3.

Of the 1 ÷ 4 schemes, I prefer the right-hand one because it provides the better symmetry. In lieu of the bifilar windings on T2 and T3, coax can be used.

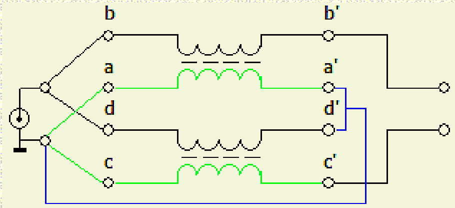


Winding scheme for a 1 ÷ 1 balun.

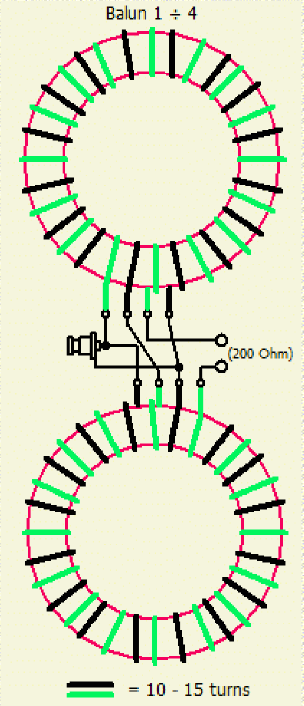




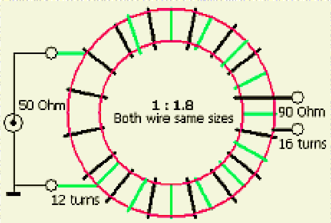
Winding schemes for 1 ÷ 4 baluns.



The principle of the 1 ÷ 4 system.

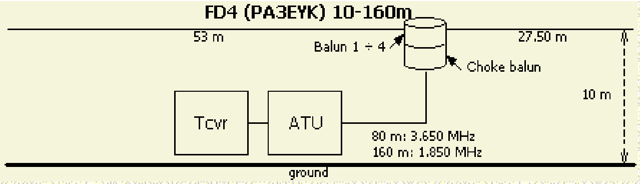


Winding scheme for a 1 ÷ 4 balun.



Winding scheme for a 1 ÷ 1.8 balun.

A simpler but still effective way of feeding an FD4 is a single 1 ÷ 4 balun and an ATU. Most often the SWR then is less than 2 ÷ 1, which an ATU in or near the transceiver can handle without appreciable losses. That avoids the somewhat difficult task of making a 1 ÷ 6 or 1 ÷ 7 transformer. On the lower bands, a 1 ÷ 4 balun provides a lower SWR than a 1 ÷ 6 or 1 ÷ 7 transformation.



4 ÷ 1 Baluns.

EXTRA BANDS

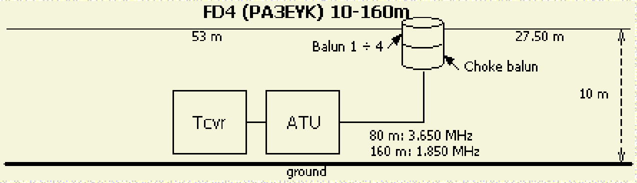
It seems that the FD3 and FD4 also have resonances in the WARC bands.

I cannot confirm this as my tests were conducted before these bands were available but LA1TNA claims the following for the FD4:

80-m SWR = 1.7	**20-m SWR = 1.5**	**12-m SWR = 1.5**
40-m SWR = 1.3	**17-m SWR = 1.3**	**10-m SWR = 1.3**

If the 13.5-m wire of the FD4 is extended to 54-m, the antenna also works on 160-m but who has room for a span of 27.7 + 54 = 81.7-m?

A FD4 and a 1 ÷ 4 balun works well PA3EYK wrote, he made an OCF antenna and used it mainly for 80 and 160-m. He experimented first with 55.5-m and 28.5-m of 2-mm diameter aluminium wire about 10-m above the ground. It is pretty bare wire, have good conductivity and a pulling force of 130-kg.



He was looking for a resonance on 80 and 160-m by gradually cutting both ends of the antenna. Finally he achieved resonance at 1850 and 3650-MHz and lengths of 27.5 and 53 meters. On the higher bands the SWR was not as good, but for him unimportant because he used an ATU to lower the SWR.



The balun was made with two T200-2 toroids and a choke balun of 6-m coax on a coil former. Everything was mounted in standard PVC housing with in the lower part the rolled coax cable. The photos will be clear enough for home brewers. I think that the inductance of about 7 µH (2 × 17 turns in series) to the secondary side of the balun is rather low for 80 and 160-m, but apparently it works to his full satisfaction.

BUYING

If the shopping for components and assembling an FD4-like antenna does not appeal to you, you will have to buy one. Several big and small antenna manufacturers offer similar products under fancy names such as OCF Windom. They continue to be secretive of the innards of their balun & matching units, and it largely determines the performance of such antennas. You only can go by the opinion of other buyers, be they expert or not.

FD4 clones.

FD4 CLONES

The manufacturer of the antenna on the right is VK3KCG. He calls his 2-part balun an 'Open Path Magnetic Balun'. The resonant frequencies with the lowest SWRs at an antenna height of 6 m are:

3.5 SWR = 1.1	**10.125 SWR = 1.7**	**24.9 SWR = 1.3**	**53 SWR = 1.0!**
3.8 SWR = 1.1	**14.250 SWR = 1.6**	**28.25 SWR = 1.1**	**–**
7.1 SWR = 1.5	**21.250 SWR = 1.8**	**29.25 SWR = 1.3**	**–**


This is yet another clone. The balun obviously is an autotransformer and the manufacturer is not secretive about it. As described above, this increases the risk of feeder radiation.

SCHWILLE DCF 77 FREQUENCY STANDARD

INTRODUCTION

If you deal a lot with equipment, for sure there comes a time that more accuracy will be an important factor. Many instruments are based on a reference source in the form of a 1 MHz or 10 MHz crystal oscillator without or with an oven, but is the frequency stable and correctly and how it can be calibrated. A reliable standard is not always available in the immediate vicinity.

A method that I used is to tune a receiver to a calibration signal of a 10 MHz beacon, monitor the oscillator and then adjust for zero beats. This requires some practice and it goes pretty good. It is not perfect, since often there is fading or the signal strength is insufficient with respect to other interfering sources. In short there is a need for a proper frequency standard.

SCHWILLE DCF 77 TYPE 860

A professional frequency standard that is locked onto a transmitter, an atomic frequency or GPS is a valuable instrument. The cheapest is a Schwille type 860 that obtains its reference from DCF77's 77.500 kHz time signal near Frankfurt. To take advantage of the transmitter, the receiver must be within a radius of about 1500 km. This limits the applicability of the device to a part of Europe, but is suitable for the Netherlands.

The price of this frequency standard was not attractive to me because my Bulova temperature-controlled 10 MHz oscillator did well. Patiently wait was rewarded when unexpectedly even two Schwilles were offered in a ebay.de auction. So I'm (fig») purchased the instrument at a reasonable cost.

To my knowledge the device is produced in Austria ia put on the market under the brand name Schwille.

De link to Schwille is: http://www.schwille.de/Pythagoras/dcf77Frequenz.html

Zie ook: http://mbr-ch.com/fpr_fn_dcf.htm

Technical Details:

Reception frequency: 77.500 KHz

Transmitter: Normal frequency transmitter DCF 77

Location: Mainflingen near Frankfurt am Main

Normal frequencies (outputs): 100 KHz, 1.000 MHz and 10.000 MHz

Level: TTL with Fan Out 30

Pulse Shape: Square wave with a 50:50 ratio

Control output: 2 Vpp signal from the transmitter

Accuracy: .... Is dependent on the measurement time

.... 1 × 10 $^{-7}$ at 1 second measurement time

.... 1 × 10 $^{-8}$ to 10 seconds measurement time

.... 1 × 10 $^{-9}$ for 100 seconds measuring time

.... 1 × 10 $^{-11}$ at 12 hours (day / night tolerance)

Field strength indicator: red 20 Segment LED bars

Receiver Bandwidth: Narrow a broad internal ± 12 Hz crystal filter

Frequency Conversion: PLL with quasi-periodic divider

Attack: After switching on approx 30 seconds

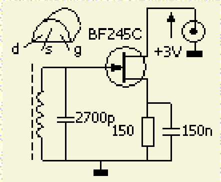
Separate ferrite with 5 m cable

Antenna Bracket: Mounting with mounting bracket

Housing: Plastic housing h × w × d, 135 × 175 × 235 mm

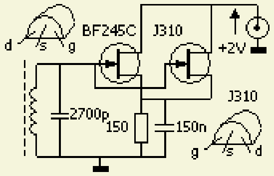
Voltage: 230 Volts AC 50 - 60 Hz 5 VA

FERRIET ANTENNA



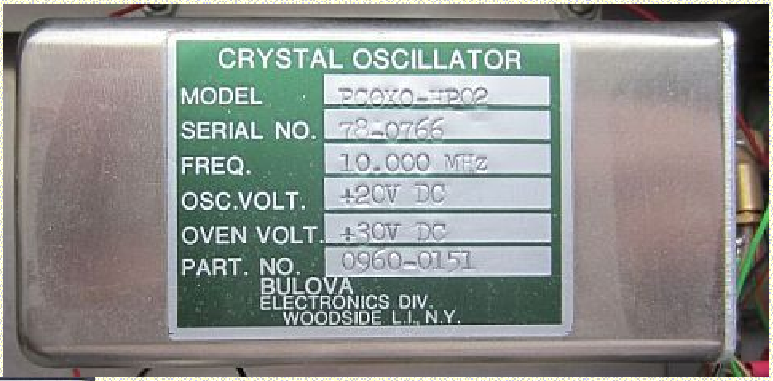
The standard is equipped with a separate ferrite antenna in a plastic housing. This is connected to the device with a 5 m long and thin shielded cable. The circuit is in resonance with a 2700 pF capacitor and is amplified and

buffered by a BF245C FET. The signal is tapped from the drain through a 3 V supply line.



The reception in my shack was not optimal and more gain would be welcome. When comparing the parameters of BF245C and J310 the last is more suited. By way of experiment, I installed («fig) a J310 parallel to the BF245C. According to the LED indicator the received signal was maximum! The voltage on the supply line was 2 V, a sign that the current is increased. Presumably, with only one FET a same effect is achieved by reducing the source resistance, but I have not bothered to do anything to change.

BULOVA KRISTAL OSCILLATOR



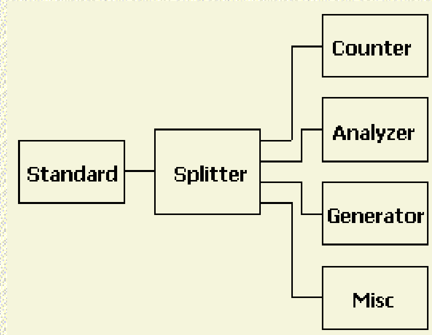
I used as reference source an (fig ») oven stabilized 10 MHz Bulova/HP crystal oscillator. The system is housed with a power supply in an emptied HP cabinet. The Bulova is an extremely stable product. Even if not permanently on or occasionally into action, after about 10 minutes the frequency is exactly 10 MHz. This is monitored with even more stable standards.

TYPE 860 IN ACTIE

How the 860 device is functioning in practice? If its 10 MHz output and a 10 MHz crystal oscillator (here Bulova) are coupled to a double-ray oscilloscope, the figures are not moving if the two frequencies are exactly the same. If not, you need to calibrate the oscillator.

However, due to fading the 10 MHz locked output winds its way to a limited extent. In these circumstances I calibrate an oscillator to the centre of that "drift". Practice has proven that this is a good method. The Bulova stays unwavering if it is set on frequency.

SPLITTER



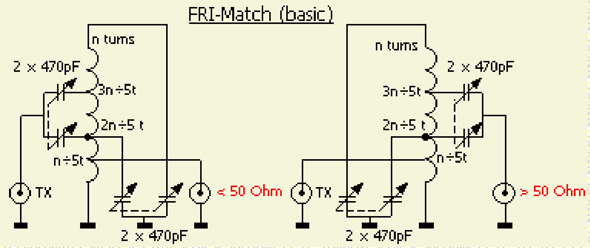
To feed various instruments with a stable 10 MHz time base a splitter with 4 outputs is used. The dingy box was purchased initially and stored for BNC connectors and possibly to encase a project. In a later stage the box was cleaned and polished and then it turned out to be a 3 MHz - 200 MHz professional splitter!

« Back

FRI-Match ATU, a single-coil Z-Match type:

(Freematch line matching unit etc. published in RSGB's RadCom 1989 july and a recent version of Rothammel's Antenna Book.

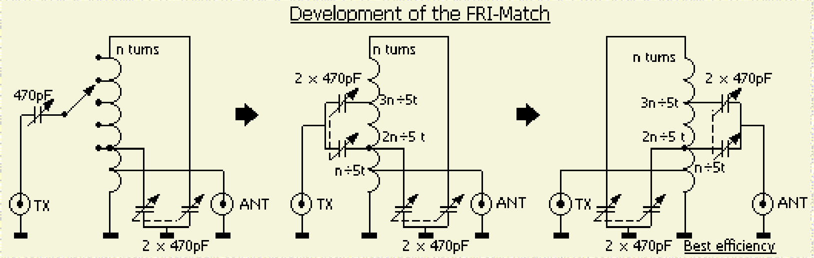
UPDATE **13-oct-2016**

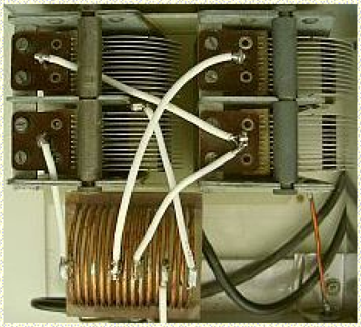


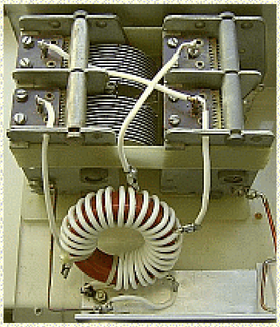
DESIGN

This ATU, I call my design FRI-Match, has been devised in 1972 as an unbalanced tuner for improving the SWR at the transmitter end of coaxial feeders to resonant antennas (eg verticals, dipoles, trapped dipoles, G5RVs, Yagis, loopquads etc.).

PAT Hawker wrote in Radio Communication: "surprisingly, it seems to have attracted relatively little attention when it featured in TT July 1989. In view of the current interest in this approach it seems worth repeating this pioneering 1989 item".







It is a modified version of the well-known Z-match and is designed as the result of experiments in reducing the SWR on the five HF bands between 3.5 and 28 MHz (incl. the WARC bands) without the necessity for switching coils and with a minimum of knobs.

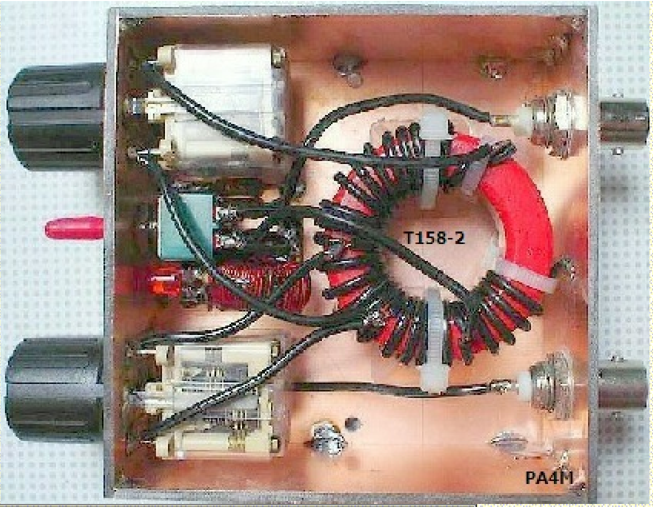
Tom Seed, ZL3QQ, has published a basically similar approach with a detailed explanation of the theory of operation in BREAK-IN March 1992. Bill Orr, W6SAI, has featured this ATU in the August and September 1993 issues of *CQ*.

After experimentation with various antennas and complex loads, one 5 - 8 µH coil tuns out to be the best tuning system for 10 to 80 m. The efficiency of the tuner is good, because it can be considered as an auto transformer with inductive and capacitive taps on the coil. Originally the design was a three knobs tuner (the left model). The results of further experiments were the middle and right model (with two knobs). The twin varicap has almost the same effect as the switched capacitor at the input of the left model. So a switch could be saved.

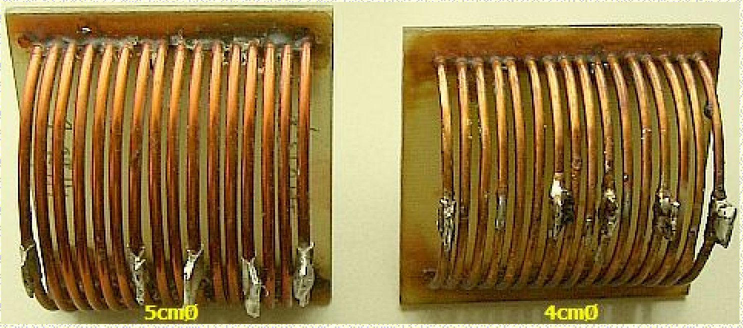
One of my first constructions was with two tiny plastic varicaps as used in portable AM radios.

Although intended for QRP, they were often suitable for even 100 W if the loaded impedance was relative low, e.g. very close to 50 Ohms. My QRP ATU no longer exist, but accidentally PA4M build a device (fig ») almost similar to my former unit.

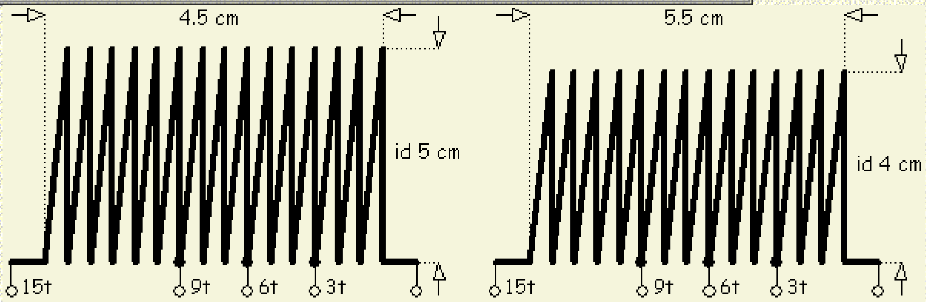
COIL INFORMATION



COIL		
Long	4.5 cm	5.5 cm
ID	5 cm	4 cm
Turns	15	15
Taps	3, 6, 9	3, 6, 9



Wire diameter of at least 1 to 2 mm.



The coil is made with: 15 turns of 2.5 mm diameter enamelled copper wire or 6 mm² tinned copper wire, 4.5 cm long with 5 cm ID or 5.5 cm long with 4 cm ID. Taps on 3, 6, and 9 turns from earthy end.

CALCULATION OF THE TAPS

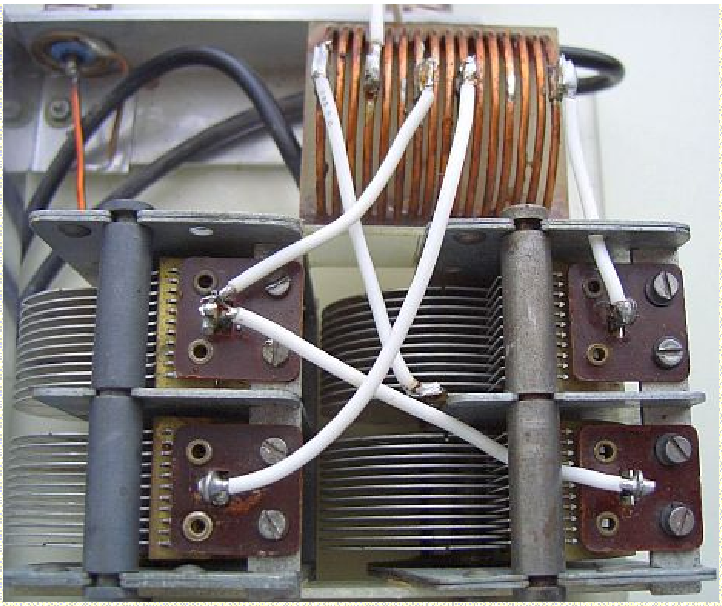
If random sized 5 – 8 µH coils with n turns (see PE1ADY's ATU) are used the taps for equal efficiency on all bands should be at:

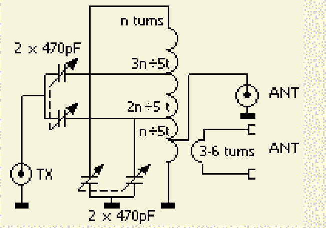
Coil	Random size but: ± 5 – 8 µH
Turns	n
Tap 1	n ÷ 5 turns from earthy end
Tap 2	2n ÷ 5 turns from earthy end
Tap 3	3n ÷ 5 turns from earthy end

PRACTICE

It is essentially a 'kiss' approach cheaper and almost faster than an automatic ATU provided that the calibrated settings on each band for minimum SWR are known so that the capacitors can be quickly reset.

In practice the ATU has proved more flexible than expected and in many cases permits matching to non-resonant antennas.

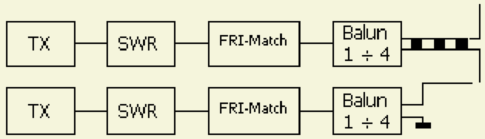




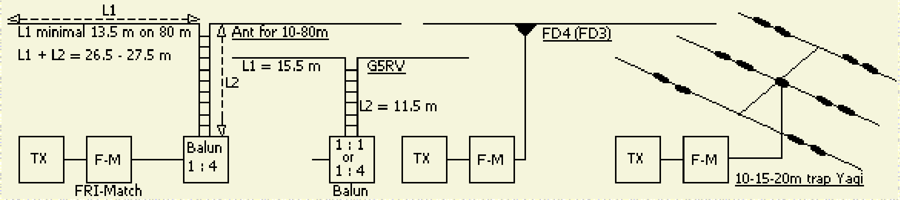
With an extra 3 – 6-turn bifilar winding over the earthy end of the coil (fig») a "balanced" output for 50/75 ? twin wire or 300 ? ribbon feeder is feasible.

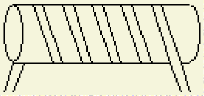
However, it should be noted that this design couldn't satisfy all possible conditions such as random length wires and antennas. This can sometimes be overcome by increasing or decreasing the length of the coaxial feeder or ladder line and/or reversing the input/output thermals of the ATU. To meet all possible matching conditions a more complex arrangement should be necessary.

MATCHING ANTENNAS



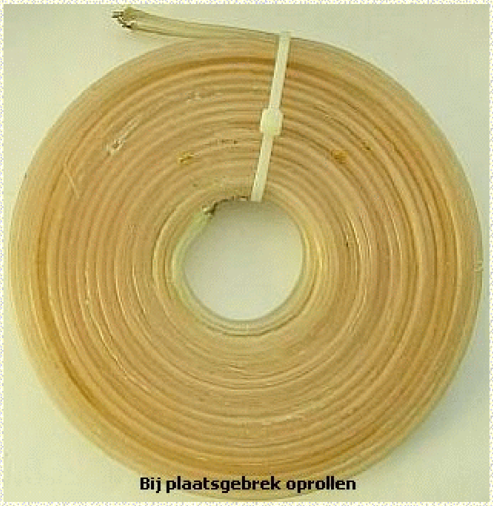
With this FRI-Match I do not recommend the use of a coupling coil but have the preference for a suitable balun at the output of the ATU.





The coiled ribbon performs similar as a choke balun.

If limited space in the back garden occurs, roll up the ribbon.



Roll up if there is too little space.

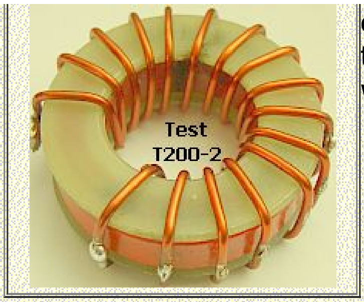
TOROID

Toroid	**T200-2**
Turns	**25**
Taps on	**5, 10, 15**

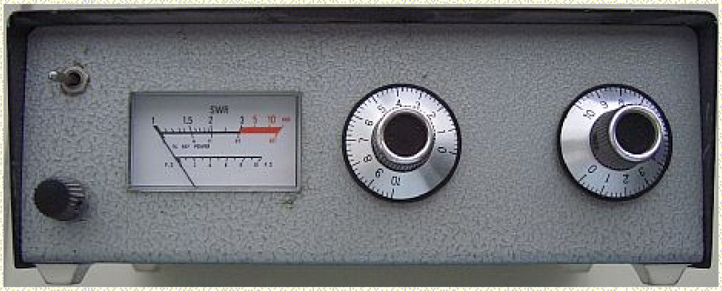
A toroid, self-shielding because oh it's low external field, facilitates compact construction. For ± 400 W power, a T200-2 toroid can be used with 25 turns on 75% of the circumference

Taps 5, 10 and 15 turns from earthy end. A 5 to 8 μH coil seems to be the best as the result of experiments.

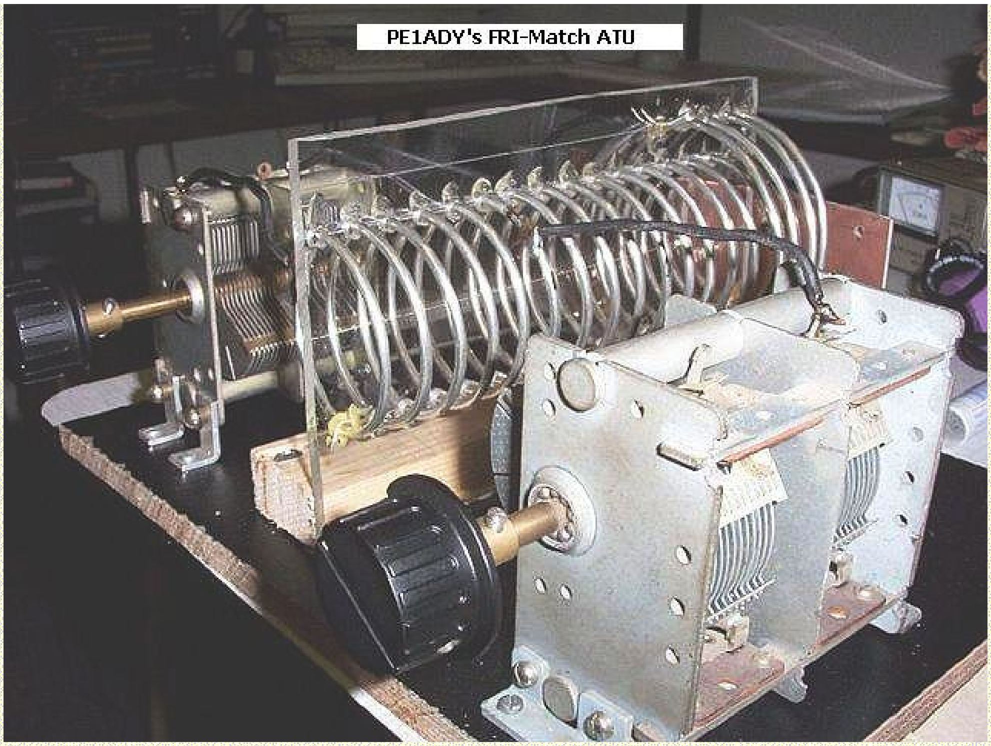
Before winding, several layers of Teflon plumbing tape must be applied to the core, to insulate it from the coil-windings. Another method of insulation is to cement two flat isolating washers (e.g. made from bare glass fibre board, see figure) on each side of the bare core. Apply a small quantity of super glue, possibly only a few drops, around the sides of the core. Work swiftly; the glue hardens quickly. The glue prevents the washers from moving out of alignment while the core is being prepared for winding. For a T200-2 core, the inner diameter should be 28 mm and the outer diameter 55 mm. With this last

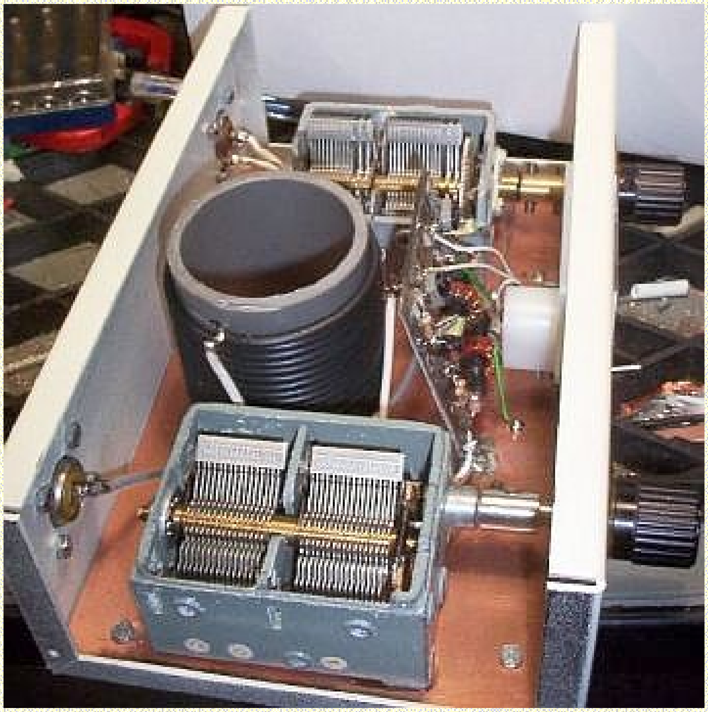


construction it might be even possible to use bare copper wire for the windings.



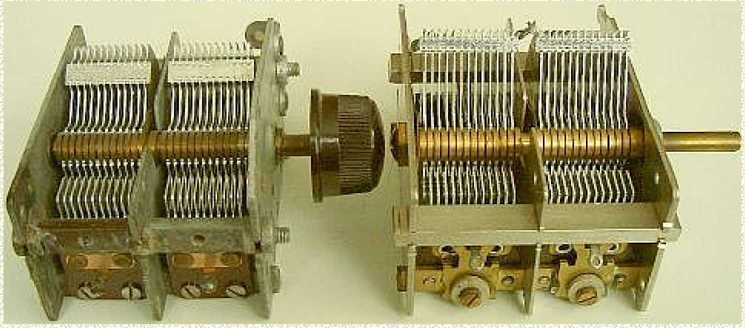
Home-made ATU (w × h × d), 17.5 × 6 × 12 cm with a T200-2 toroid.



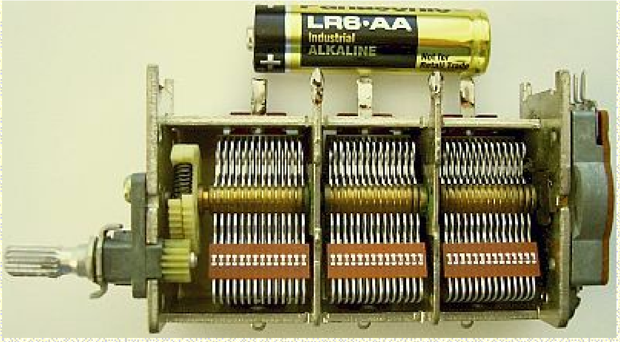


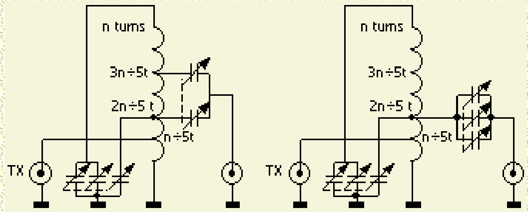
PE1ADY's home-made FRI-Match ATU's.

CAPACITOR INFORMATION



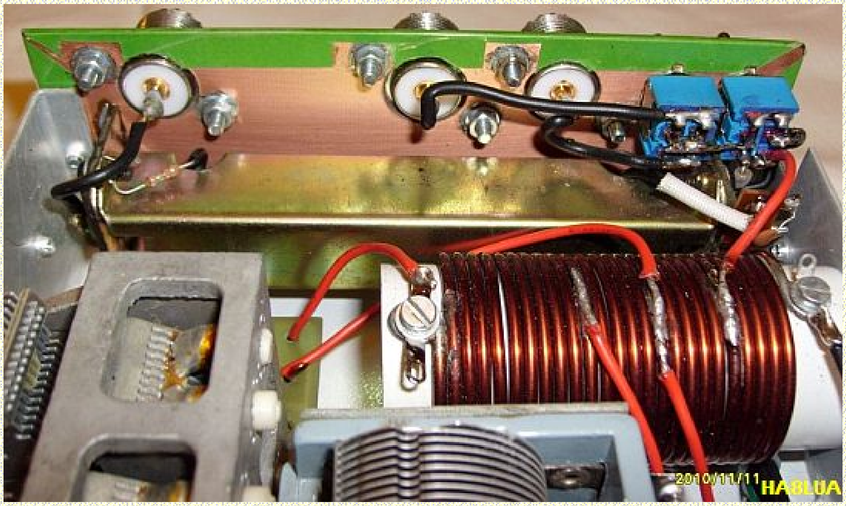
Twin-gang from vintage AM radios

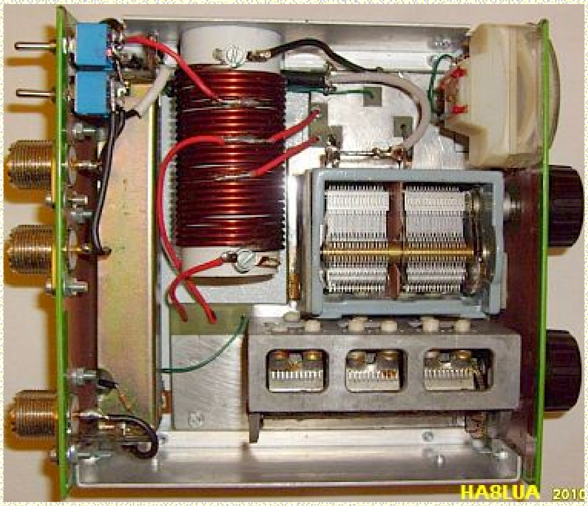




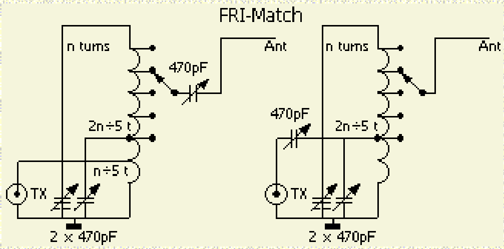
Variable capacitors can be receiver-type twin-gang 10 – 490 pF per section, for power up to 400 W. For QRP to 100W operation a T200-2 toroid and two air-dielectric variable capacitors salvaged from vintage AM radios can be used. If 2 × 350 pF capacitors are used the coil should be increased to about 8 µH. If 3 × 350 or 3 × 490 pF are used in some cases the FRI-match permits limited matching on the 160 m band. It will then still work on 10 m.

HA8LUA:"I looked for a really little portable ATU which is very universal (can be used with all my field day antennas: doublet with ladderline, G5RV, FD3, verticals, etc.). A few years ago I built a Z-match QRP ATU for my FT-7 and it worked fine! I have a FT-897D now, that's why I needed a 100W model. The Z-match principle was given for me and I read PA0FRI's very-very nice article on his website. The result":





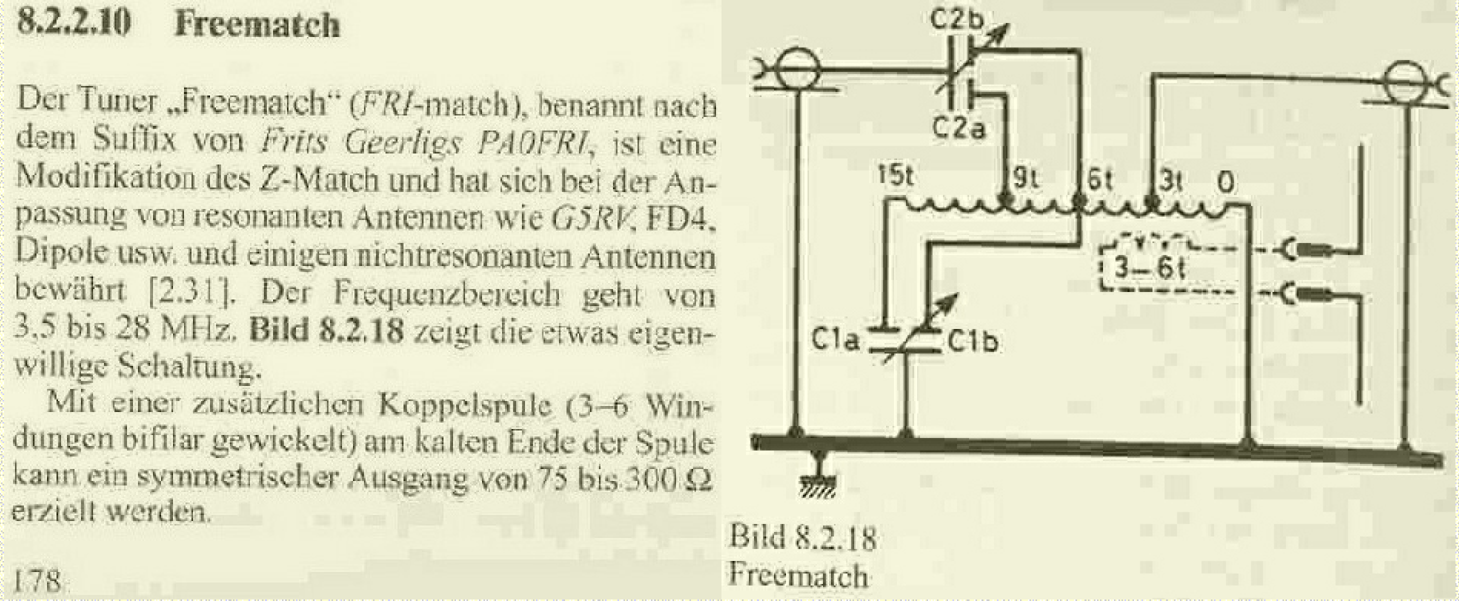
MATCHING WIRE ANTENNAS



ANTENNENBUCH KARL ROTHAMMEL [DM2ABK, Y21BK (SK)]

In Karl Rothammel's famous Antennenbuch a lot of information is published about antenna systems, tuners, coaxial cables, etc. It is a good informative reference book. My original 1978 book was printed in the former GDR on a cheap

type of newsprint. An owner of a much newer version discovered that my design was also published in the Antenna book and that is nice to know.


8.2.2.10 Freematch

Der Tuner „Freematch" (*FRI*-match), benannt nach dem Suffix von *Frits Geerligs PA0FRI*, ist eine Modifikation des Z-Match und hat sich bei der Anpassung von resonanten Antennen wie *G5RV*, FD4, Dipole usw. und einigen nichtresonanten Antennen bewährt [2.31]. Der Frequenzbereich geht von 3,5 bis 28 MHz. **Bild 8.2.18** zeigt die etwas eigenwillige Schaltung.

Mit einer zusätzlichen Koppelspule (3–6 Windungen bifilar gewickelt) am kalten Ende der Spule kann ein symmetrischer Ausgang von 75 bis 300 Ω erzielt werden.

178

Bild 8.2.18
Freematch

REVIEW

Review and experience of professor R. Jayaraman, VU2JN.

To make a long story short, my Fri-match ATU was completed in March 2011, nearly half a century after I first thought of building an ATU! Fig. 4 shows a photo (fig») of this ATU. It has just 2 controls, and no rotary inductor. It outperforms the conventional Z-match with regard to ease of tuning and tuning range, and is almost as good as the SPC Transmatch. And interestingly, so long as the Fri-match ATU is able to match an antenna within its tuning range, it is able to bring down the SWR to exactly 1.0. This is something that I had not expected from a 2-knob ATU that is free of the burden of a variable inductor! No reduction drives are used in this ATU. Though the tuning of the condensers is very sharp, it is manageable, even for a person aged 75 years! An analog SWR bridge is needed for tune-up. A point to be kept in mind is that, if one of the condensers is very much off-tune, tuning the other condenser would not produce any dip in the reflected power. Therefore, in the absence of calibrated dials, visual monitoring of the condensers is necessary. The body of one of the condensers has a RF potential but, since it is tied to the transmitter output, there is no hand-capacitance effect.

The Fri-match ATU sits to my right near the front edge of the operating table, not far away from the FT-840 transceiver. From the antenna switch, a 70-ft. length of RG-223 coax feeds a 40-metredipole antenna, and a 50-ft. length of RG-213 coax feeds a HY-GAIN 12AVQ 3-band ground-plane antenna. The ATU enables me to use the 40-metre dipole on 20, 40 and 80 metres, and the 12AVQ ground-plane on 10, 15, 20 and 40 metres --all with a SWR of 1.0 as seen by the transceiver. So much so, the ATU is useful even when a resonant antenna is used for the band of operation. On 20 metres and the higher bands, I normally use the 12AVQ ground-plane. The only time I operate with a non-resonant antenna is when I use my 40-metre dipole on 80 metres. Signal reports then indicate that I am roughly 1 S-point weaker than similar stations using a 80-metre dipole. That's not bad, and I am quite happy with the performance of the ATU.

I recommend this ATU to all hams. When an ATU is available, we can fabricate a dipole, ground-plane or any other antenna simply to the dimensions suggested by theory, and dispense with the trimming of the antenna. In many situations, trimming of the antenna to lower the SWR is unscientific, because the problem is not in the antenna, but elsewhere! It is better to rely on the ATU to take care of the fine tuning of a resonant antenna.

-- VU2JN.

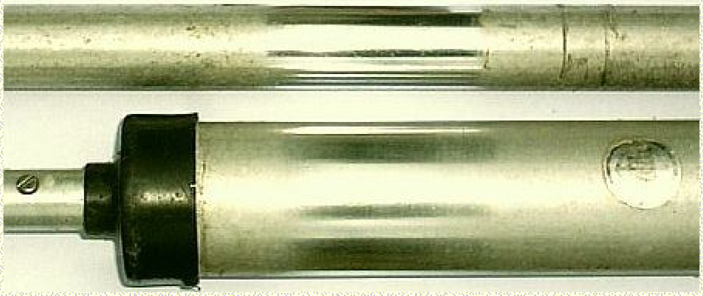
See original topic of professor R. Jayaraman, VU2JN: Frimatch-ATU .

«Back AØFR

FRITZEL TRAPS, BALUNS AND ELEMENTS

MAINTENANCE

Every time there is a reason for an antenna to get down, I inspect the antenna and do the necessary maintenance.

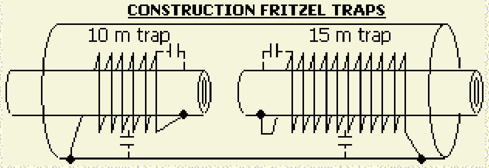


Many hams sometimes neglect the maintenance of an antenna, but it is essential to your antenna system. As an example see Fritzel's (wave) trap. My more than 35 years old Fritzel antenna elements look new after a thorough maintenance. Oxidation created pits and bumps on the elements. By regular "polishing" the surface becomes smoother and oxidation has less chance to penetrate the elements. Even dirt will not stick easily on the outside. The cleaning should be done with (fig») metal soap pads such as "Brillo".

Use a soap pad.

The traps are made with soft aluminium wire and after some time that is covered with cobwebs and oxidation, especially against the vent of the outer tube. If you want to replace the aluminium look for companies that provide fencing for farmers. Cleaning of a coil with a Brillo pad is possible, but it pretty much removes aluminium. The wire becomes flatter if you do the cleaning regularly. It is better to clean (fig») with an anti scratch sponge (Spontex) used for cleaning pans. To protect the coils I sprayed it with a lacquer that was used for making sparking cables water-resistant. It may be removed with thinner. Even a treatment with silicone spray works preservative on the coils and antenna rods.

TRAP



In principle, a trap is a capacitor in parallel with a coil. In Fritzel types you don't see a capacitor («fig) because the coil and the aluminium tubes works as an " capacitor ".

With two screws the interior may be removed. Further in this article describes how with a dipper the dismantled trap is measured. This can be useful in detecting a defect if on a particular band the SWR of your antenna is not good anymore.

CORROSION

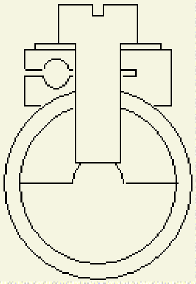
Corrosion caused white crystals inside the case and on the wire and aluminium rod. If that process has taken a long time it may be difficult to push the trap out of the case. With back and forth motion the crystals works as sandpaper so you may manage it (usually). I have not (yet) tried, but maybe it goes better with a spray of WD40.

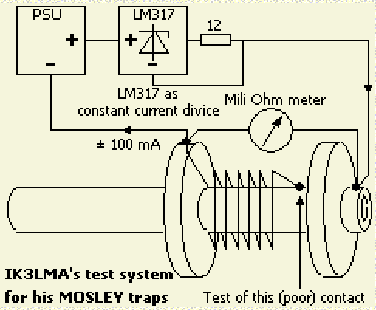
Fritzel 15 en 10 m traps from a 3 bands dipole of a FB13, FB23 of FB33 (< 1983).

Everything in my vintage 1970/71 traps is fixed with screws but it shows that in later types they were partly replaced by rivets. The revited joints are not always perfect and together with the aforementioned crystallization create a poor contact or even a break.

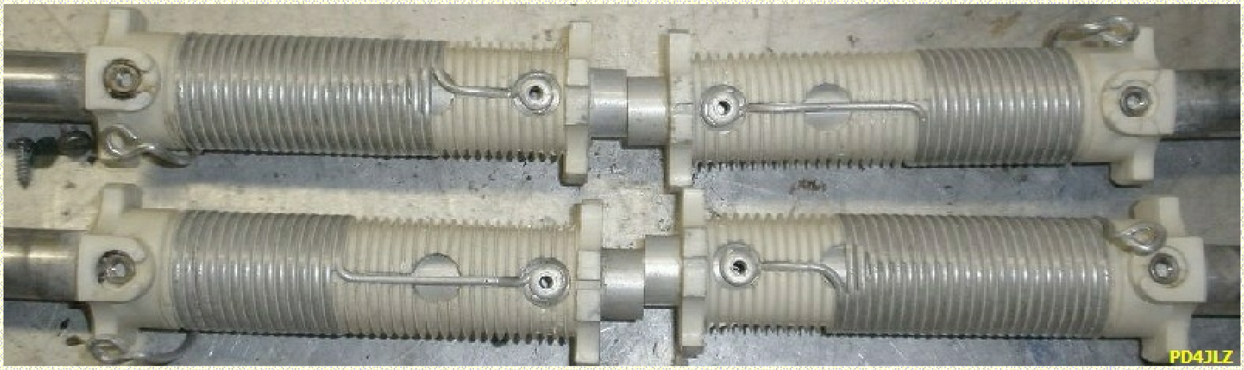
For example the antenna resonates only on two bands, but does not work to the third one. The contact is apparently sufficient for the current through 15 m coil (for the 20 m band), but insufficient as parallel circuit (trap) for the 15 m band. Drilling of the rivet and replaced by screw or bolt with nut is than the only cure.

Shortly after the acquisition of Fritzel by HOFI HF-Technik the company has patented a new clamp. The contact surface is 45 times increased compared with a wire eyelet plus rivet. DO1YWF received this message in response to HOFI after he had reported his bad experience with the contact. I have drawn (fig») the clamp as best as possible from his enclosed PDF file.





Despite my article in Dutch IK3LMA clearly understand the text, because he wrote me that the problem occurs also with his traps of two Mosley beams. They are almost similar to the types of Fritzel. In contrast to the contact of coil with tube, is visual inspection of the connection to the rod antenna not to perform. To measure accurately he uses a digital mΩ meter in conjunction with an LM317 as an approximately 100 mA constant current source. The meter indication is almost correct in mΩ. He was shocked by the result and therefore recommends to one another to really measure and not rely on a visual inspection



The rivets replaced by stainless steel bolt and nut.

Drilling of the rivets and replaced by stainless steel bolts and nuts is the surest way to be spared from (future) malfunction of the traps.

Remember when replacing the traps that the coils with the least windings are for 10 m. They should assembled directed to the feed point of the antenna. When the antenna is remounted you're not the first to discover that the SWR is poor due to a wrong installed trap.

The screwed fastening (fig») at the other side of the coil also require maintenance. Remove oxidation, dirt and apply silicone grease as a protection to.

DIAMETER TRAPS

The production of antennas by Mr. Fritzel is ceased because he is deceased. His company produced many types of antennas and later then 1982 they made antennas for more power. If you want to buy something 2nd hand, look at the size of the traps, the

diameter of the tubes and the version of the balun. The case of the older type trap has a diameter of 4 cm and the diameter of the newer model is 5 cm. The thickest aluminium rod in the new model has a diameter of 28 mm.

COVER CAPS

Damage due to a dirty (vintage) trap and exceeding the power.

Top: Fritzel model 83 trap,

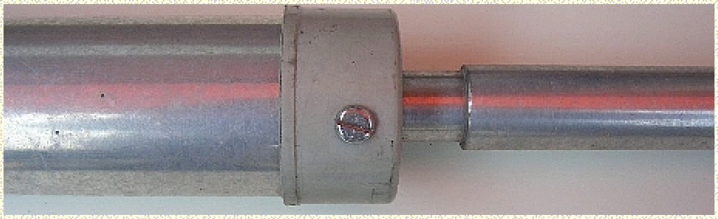
Bottom: arcing and damage in a 1970/71 trap.

The black plastic caps will eventually crack or split and a replacement are not easy to find.

TIGER PLASTIC had suitable caps (for broomsticks and chair legs), but are apparently no longer for sale.

From Germany I am reported that HOFI www.hofi.de sales caps. HOFI continued the production or sale of Fritzel products.

See for Spare parts etc.: http://www.hofi.de/pdf/Preisliste%20Fritzel%204109%20%281-4%29.pdf

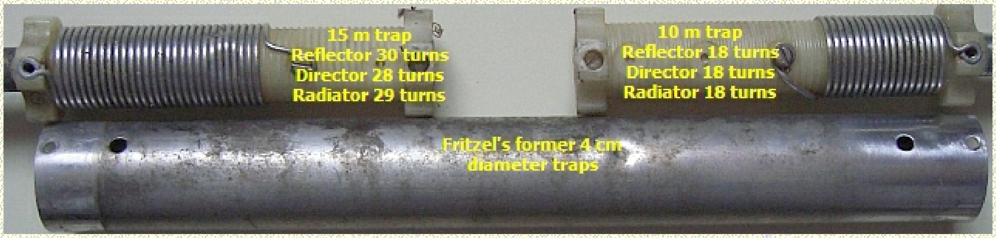


I used («fig) standard plastic (PVC?) caps as replacement for the original types. The are suited for the present 5 cm diameter traps and with a punch I made an appropriate hole in the centre. So it fits exactly on the aluminium cover of the trap. If only the tip of the plastic coil form is applied with some silicone grease you ensure that the construction remains "water resistant". Because weather the grey colour of the caps become almost white.

K3LMA wrote about this subject: "For sealing the plastic end cover is very useful the polyurethane foam used by car body repair, tested by myself over 10 years on my location, with very good result".

Anything: "Last suggestion born after looking the external aluminium tube cover. If this tube are short as on classical 10 to 20 meter band traps (± 20-25 cm length) the overall design appear good. Vice versa with the longer traps as used for the 40 meter band (length 45 cm)I have observed which the tube aren't round but are oval. I think which the blowing wind flexed the element and the repeat movement modified the tube just with localised stress just where the electrical contact are made. This can be the reason for future failure or reduced efficiency. My proposal fix (not tried) is to add two extra screws at 120 degree each to the other so to distribute the stress along the circumference insulator".

The photo shows how many windings the 4 cm Ø traps have for the radiator, director and reflector. If there are no more marks for assembling you may recover the antenna. With some very old



antennas the traps of radiator and director are equal.

PWR TRAPS 4 cm Ø

NOTE: In my oldest Fritzel Catalogue 1970/71 the 4 cm diameter traps of the (<1983) antennas FB-13 FB-23 FB-33 were only suitable for an PA-input: 1 kW AM / CW and 2 kW. That means about 500 W/CW and 1 KW/CW, SSB transmit power. Momentary more power is possible, but if they are oxidized or contaminated by insects, arcing may occur.

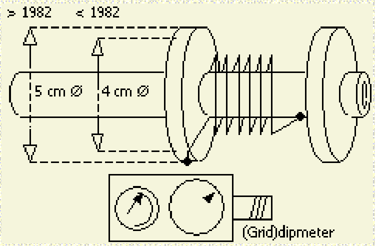
In 1973 Fritzel specified his antennas and traps for an PA (input!): 1 kW input/AM, CW, RTTY, SSTV and 2 kW/SSB (without speech processor).

Later > 1973, the folders specified the HF output: 0.6 kW/AM, CW, RTTY, SSTV and 1.2 kW/SSB (without speech processor).

It's about the traps with a diameter of 4 cm, not the newer type with a diameter of 5 cm.

RESONANCE DISMANTLED TRAPS

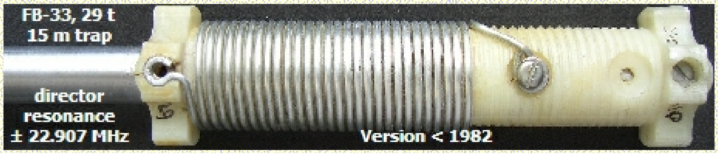
I measured my stock Fritzel bare traps with a grid dipper (fig ») or spectrumanalyzer and monitored the frequency with a 450 kHz - 30 MHz receiver. The results are about, ie ± because a dip is not 100 % accurate. Note that all measurements were done on a bare (= dismantled) trap. That means without cover and some with a not to dismantle antenna tube. Of the latter, the length depends on the year of production.

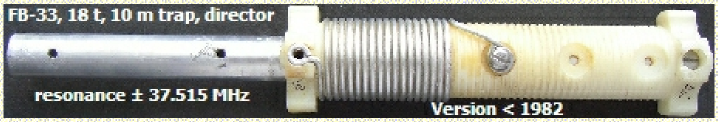


FB-13, FB -23, FB-33 RADIATOR (cover 4 cm Ø, version < 1982)

The antenna tube for 20 m (connected to 15 m trap) is not removed. By measuring the resonance it is part of the total capacitance.

FB-33 DIRECTOR (cover 4 cm Ø version < 1982)

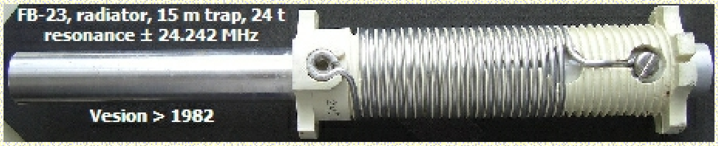


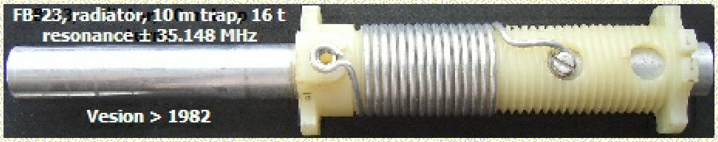


Here the director trap is the same as the FB-13 and FB-23 radiator trap. Only my director was available for measurement.

The antenna tube for 20 m (connected to 15 m trap) is not removed. By measuring the resonance it is part of the total capacitance.

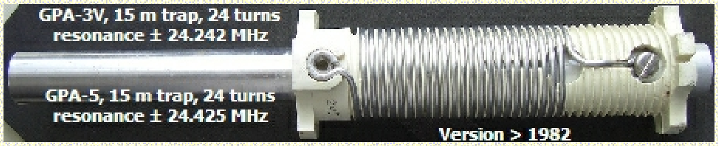
FB-13, FB-23, FB-33 RADIATOR (cover 5 cm Ø version > 1982)

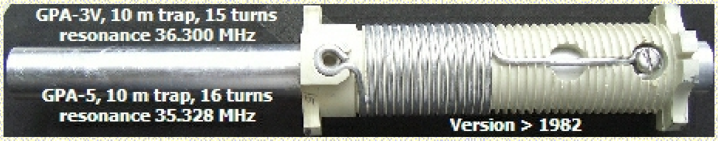




The traps of this antenna are qua, construction, size and number of turns identical to that of the next vertical antenna GPA-4. The resonance's are not so far apart.

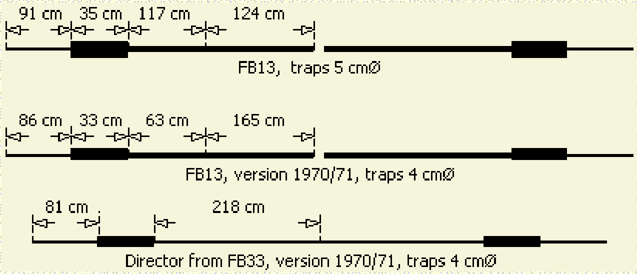
GPA-3, GPA-4 (cover 5 cm Ø version > 1982)





The 15 m traps of a GPA-3 and GPA-4 are the same in terms of construction, size and number of turns. The resonance's are respectively 24.175 MHz and 24.425 MHz. The 10 m traps of both antennas were identical in terms of construction, etc., only the GPA-3 had 15 windings with a resonance of ± 36.300 MHz and the resonance of a GPA-5 was ± 35.328 MHz with 16 windings.

SIZES FRITZEL ELEMENTS

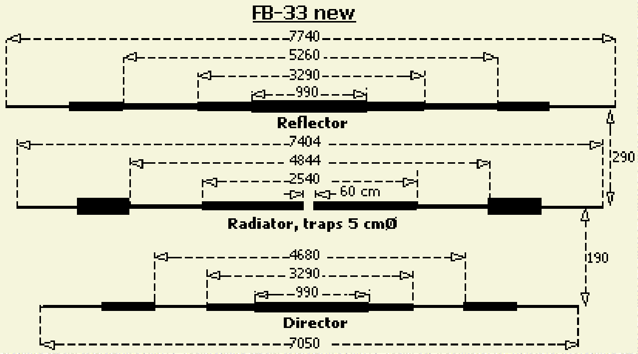


There are sometimes for sale non-original elements of Fritzel antennas and restore antennas without the right size is a problem. Often people ask me the size of the elements.

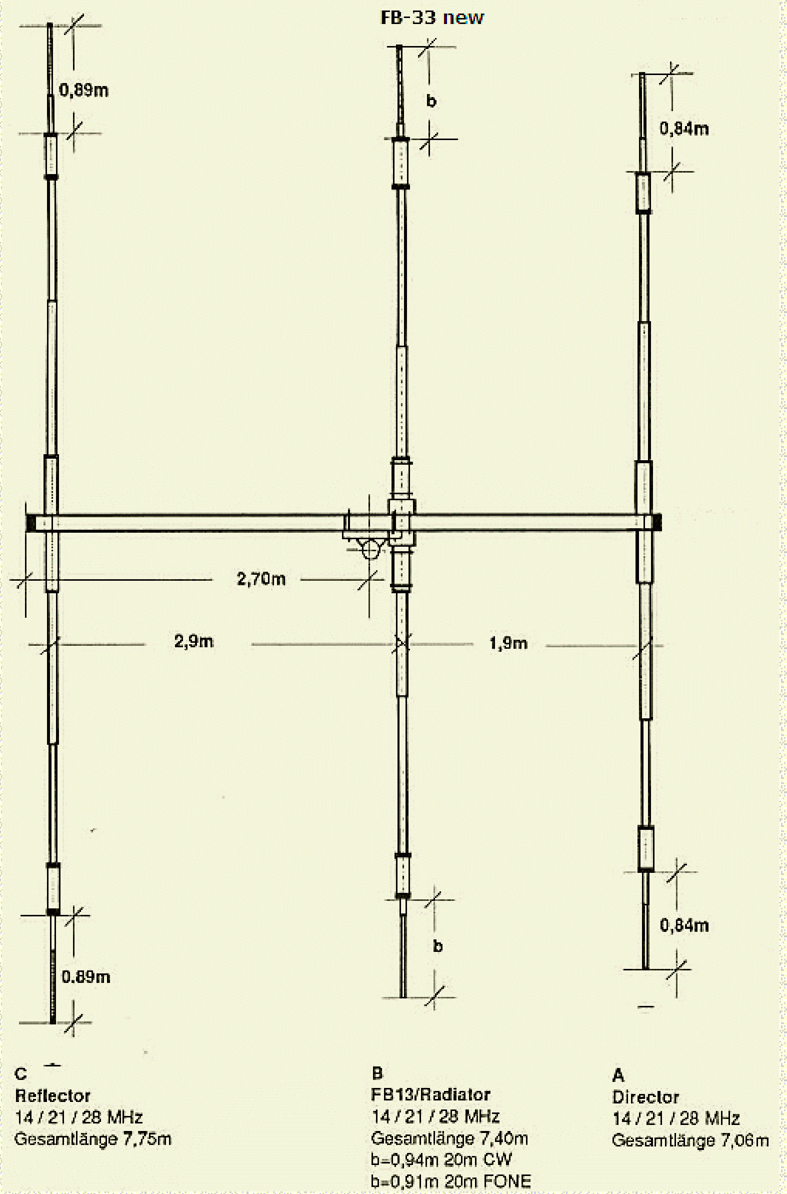
Because they are here not used for some time, it was possible to measure my stock elements.

My FB-13 dipole and a 1970/71 director both with 4 cm Ø traps worked successfully for decades as a 2 element Yagi. Later the dipole was replaced by a newer FB-13 with 5 cm Ø traps.

Unfortunately I never had a reflector so that the sizes are missing in this article.



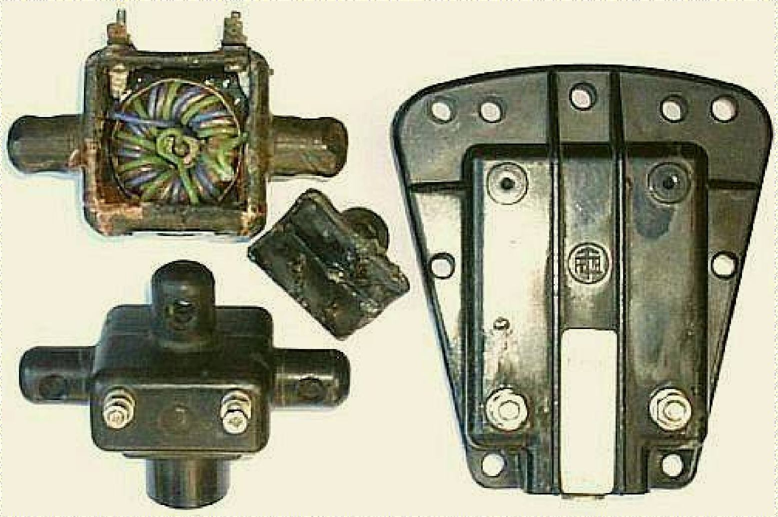
Furthermore I found in my archives the lengths between the elements of an FB-33, whose production year is unknown to me.



FRITZEL BALUNS

After 1982 the format of the baluns has also been changed.

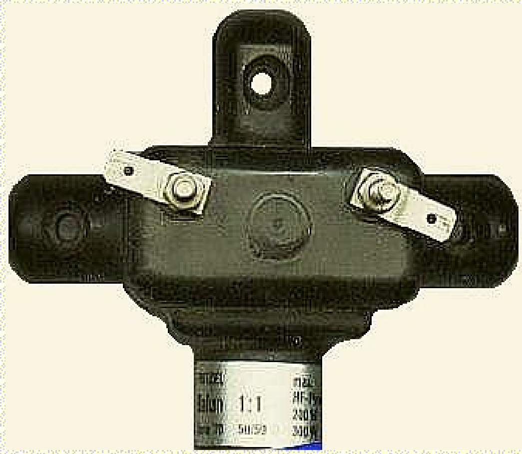
Top left shows what happens when the old model balun is overloaded with too much power or if a FD3 is used for 80 m and a FB4 used for 160 m. Apart from the permanent damage caused to the hot toroid, the shell partially melted and changed shape. The damage appears low on the picture because I restored the plastic with hot air and I glued the cracks a bit. The windings with Teflon insulation remained intact.



A («fig) 6 ÷ 1 balun of FD3 and FD4 antenna's has the same size as a 1 ÷ 1 balun. One should use an extra 1 ÷ 1 balun or choke balun to prevent radiation of the coax screen.

The power was also limited to 500 W PA input. The newer baluns are suited for more power, output 700 W/CW and 1400 W/SSB.

The larger case (right) contains a 6 ÷ 1 transformer and a 1 ÷ 1 balun. ÷ 1 balun also January 1 jacket flows appear to be so. There are baluns for even more power in the market.



Left een new "old" type 1 ÷ 1, right serie 83 type 1 ÷ 1 (1 - 50 MHz, 1500 W/CW en 3000 W/SSB).

Gemeinsame Daten der Balun Serie 83AMA Gehäuse: 2 Halbschalen aus Polystyrol, verklebt, schlagfest, schwarz, uv-fest Bruchlast: 4.500 N Anschluß: PL Ausgang Antenne: M6×20 Gewindeschrauben Edelstahl Ringmaterial: Ferrit Ringgröße: 63 × 13 mm Amplitudenabweichung 30 MHz <3dB bei 1 ÷ 1 übrige: <0.8dB SWR-Bandbreite <1.2 ÷ 1, 1 - 35 MHz bei 1 ÷ 1 übrige: 2 - 30 MHz Max. HF-Belastbarkeit bei <2 ÷ 1 SWR: SSB 1.4 kW, RTTY: 0.5 KW, CW: 0.7 kW Gewicht: ca. 0.43 kg Balun ist gebraucht,aber voll funktionstüchtig! Kpl. mit Unterlagen und Halterung in OVP.

Another couple of Fritzel balun types: left 6 ÷ 1 en right 1 ÷ 1.

TITLE>HV supply by doubling or quadrupling

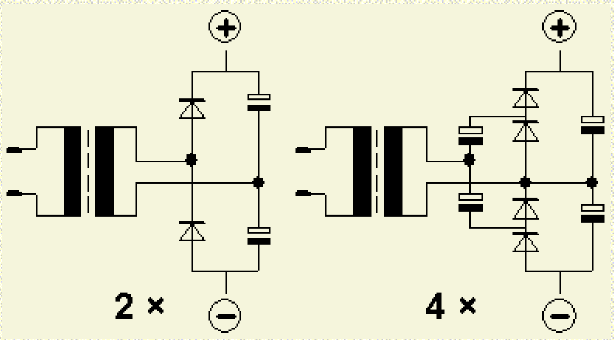
Doubler or Quadrupler 1300 V & 2200 V HV Supply

(HV supply for FRINEAR-400 RSGB's RadCom Apr 1995)

TRANSFORMER

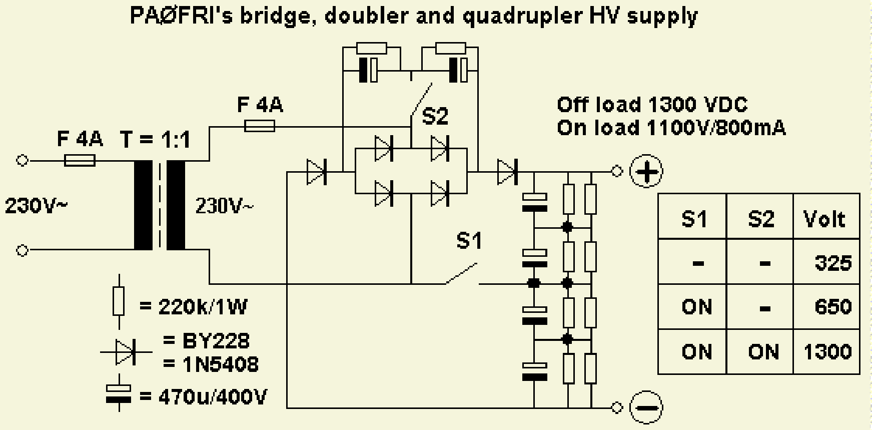
At present it is not so easy to obtain correct high-voltage transformers. Using a high-power isolation-transformer that must be of suitable rating to handle the wattage and heavy current involved in the following circuit solves the problem here.

With a doubling or quadrupling circuit (fig»), adequate high voltage can be delivered. Series-connected modern electrolytic with large capacity and high voltage (e.g. 470 µF/400 V) will give adequate smoothing and regulation during modulation peaks. They should be individually bridged by an equalising resistance of 100 kΩ (2 W). For safety reasons and adequate cooling, it is better to have two 220 kΩ or three 330 kΩ resistors in parallel instead of one of 100 kΩ.

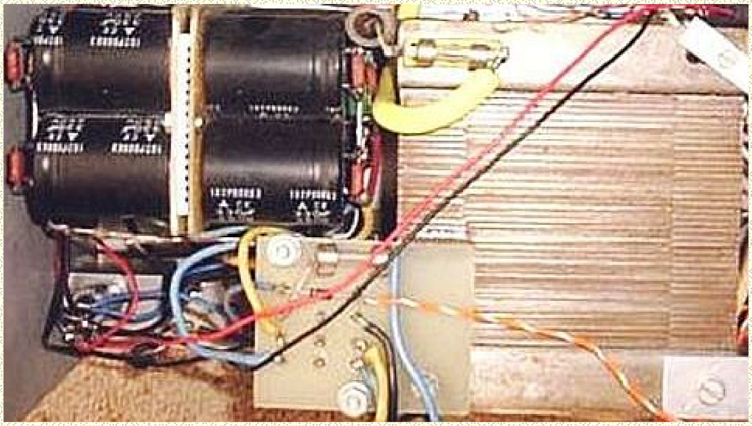


VOLTAGE QUADRUPLER PSU

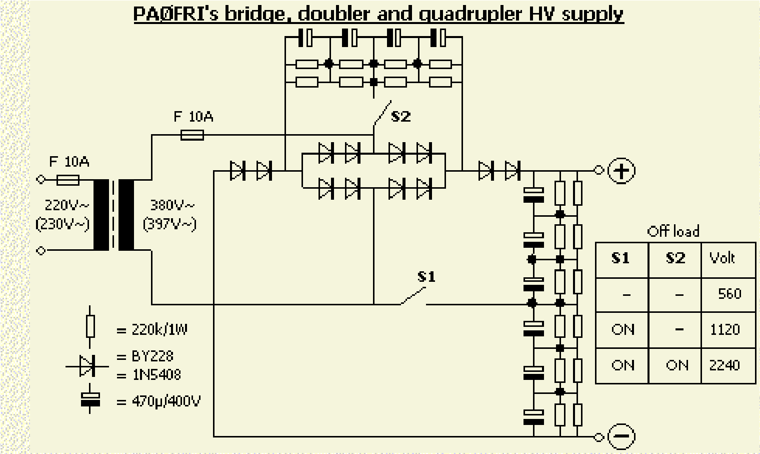
The special feature of this arrangement is that by means of two manually-operated switches, the unit provides rectification, doubling and quadrupling of the AC-voltage delivered from a 1 : 1 mains isolating transformer. Shown here is a circuit with only 6 capacitors, 6 diodes and 2 switches. I have not seen this particular arrangement published previously, so I presume that I am the originator of this type of flexible PSU.

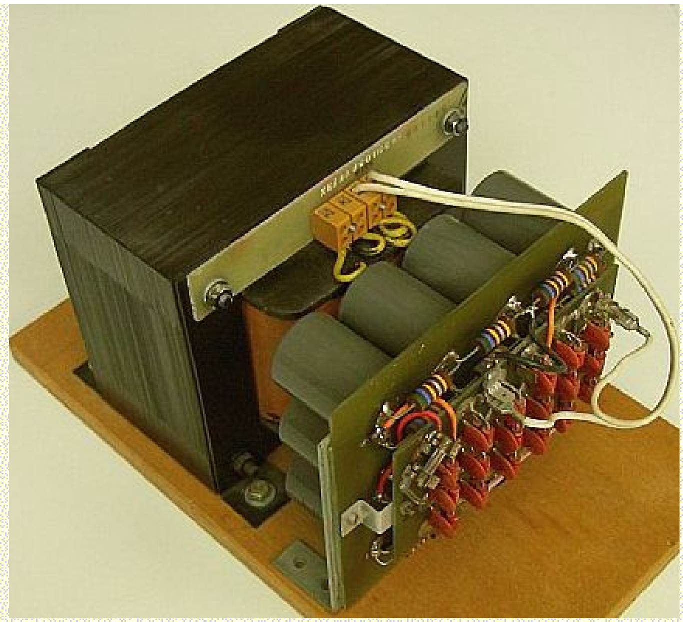


If you don't like the feature of adjusting with lowered voltage (soft-start, which prevents problems), the switches may be left out and the appropriate connections be made. The average voltage after quadrupling will be around 1150 V during SSB-transmission and around 1000 V with a constant carrier.



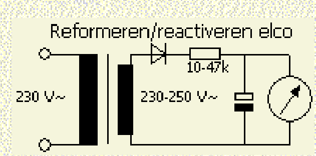
There is no soft-start delay in the power-supply as I presumed that the two switches and the internal resistance in the transformer suffice to limit the inrush current.





ELECTROLYTIC CAPS

Almost every year reducing in size.



Electrolytic cap types (range 220 µF/400 V to 470 uF/450 V) for switched power supplies are suitable for this design.

They should have their dielectric reformed first, when they have not been used for a long time. This also holds for new ones, as the date of manufacture is seldom known. Reforming is done with a 200 – 300 V supply by charging the individual electrolytic through a 20 – 50 kΩ/10 W resistor. If the leakage current and voltage are stabilised (may take minutes), the supply voltage can be raised to the intended working voltage, which should be lower than the rated one. This reforming stage can be used for testing and selecting overages electrolytic. After testing, the electrolytic should be discharged with a resistor. Normally, I use a 25 Ω/10 W resistor.

«Back
AØFRI

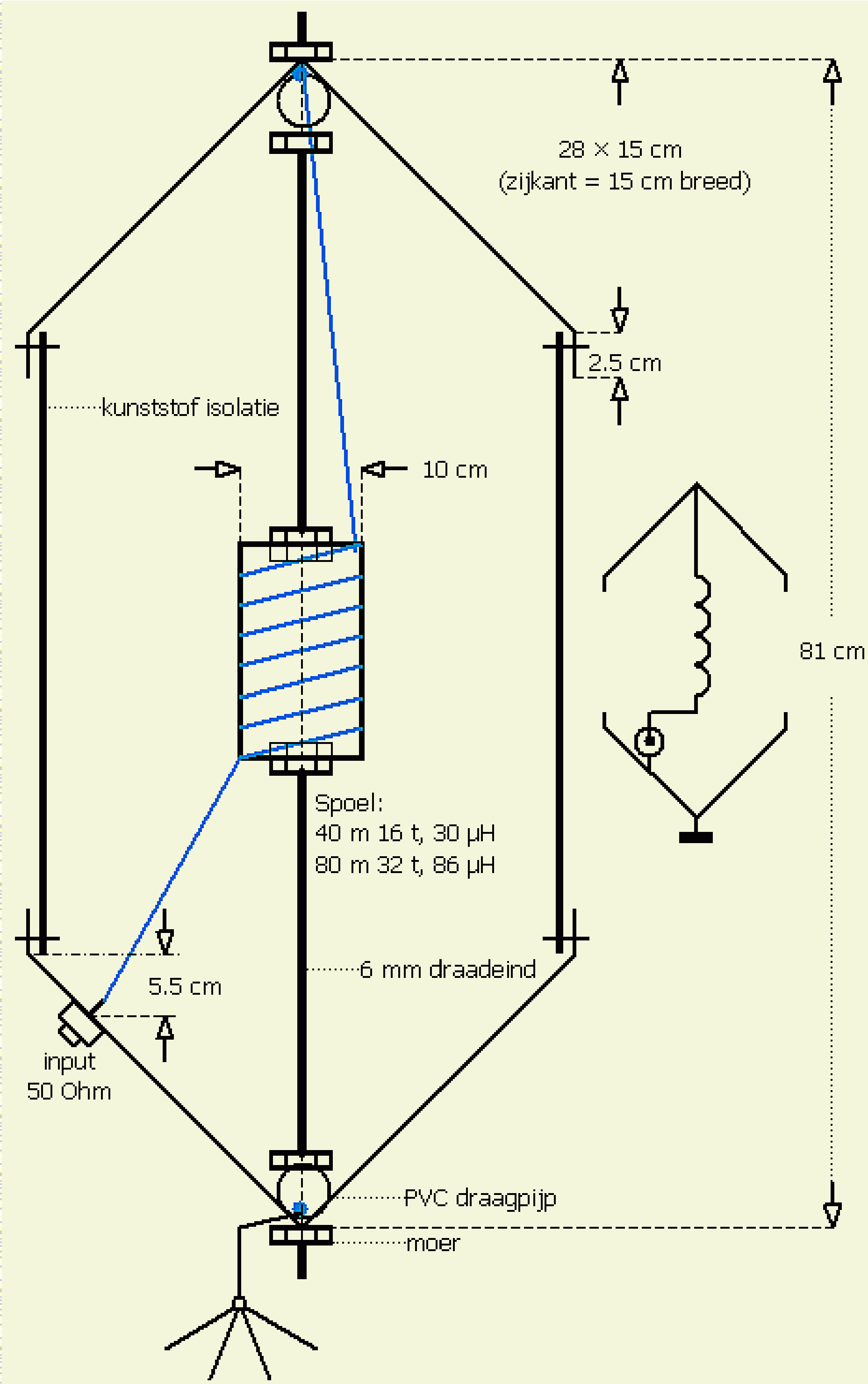
ISOTRON ANTENNA FROM PAØUNT and PA1AMS

A beautiful sample of PAØUNT.

I have no (yet) experience with an ISOTRON antenna, but Nico PAØUNT and Hans PA1AMS have tested homemade models. Perhaps you can already use the following information.

PAØUNT's ISOTRON

Nico has experienced that this antenna system works better in-house than a magnetic loop antenna.

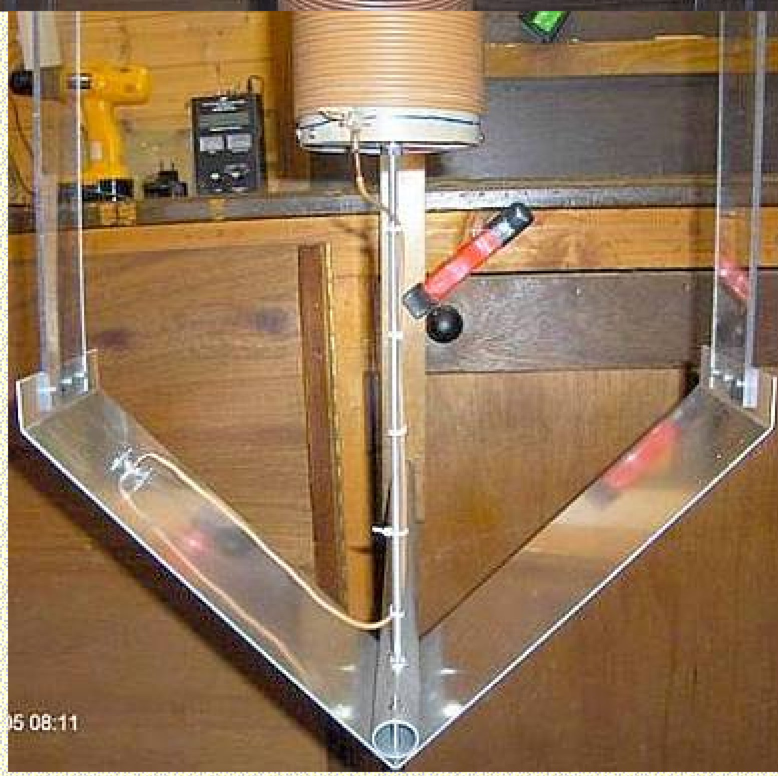


For the 80 m band the coil is wound with black 1.5 mm² installation wire of about 10 m length. With this, the antenna resonates at 3.630 MHz with a bandwidth of + and - 22 kHz. A tuner is used outside that area.

The threaded end with a 6 mm thread is interrupted in the bobbin by a hardwood stick in order not to influence the inductance.




2005 08:11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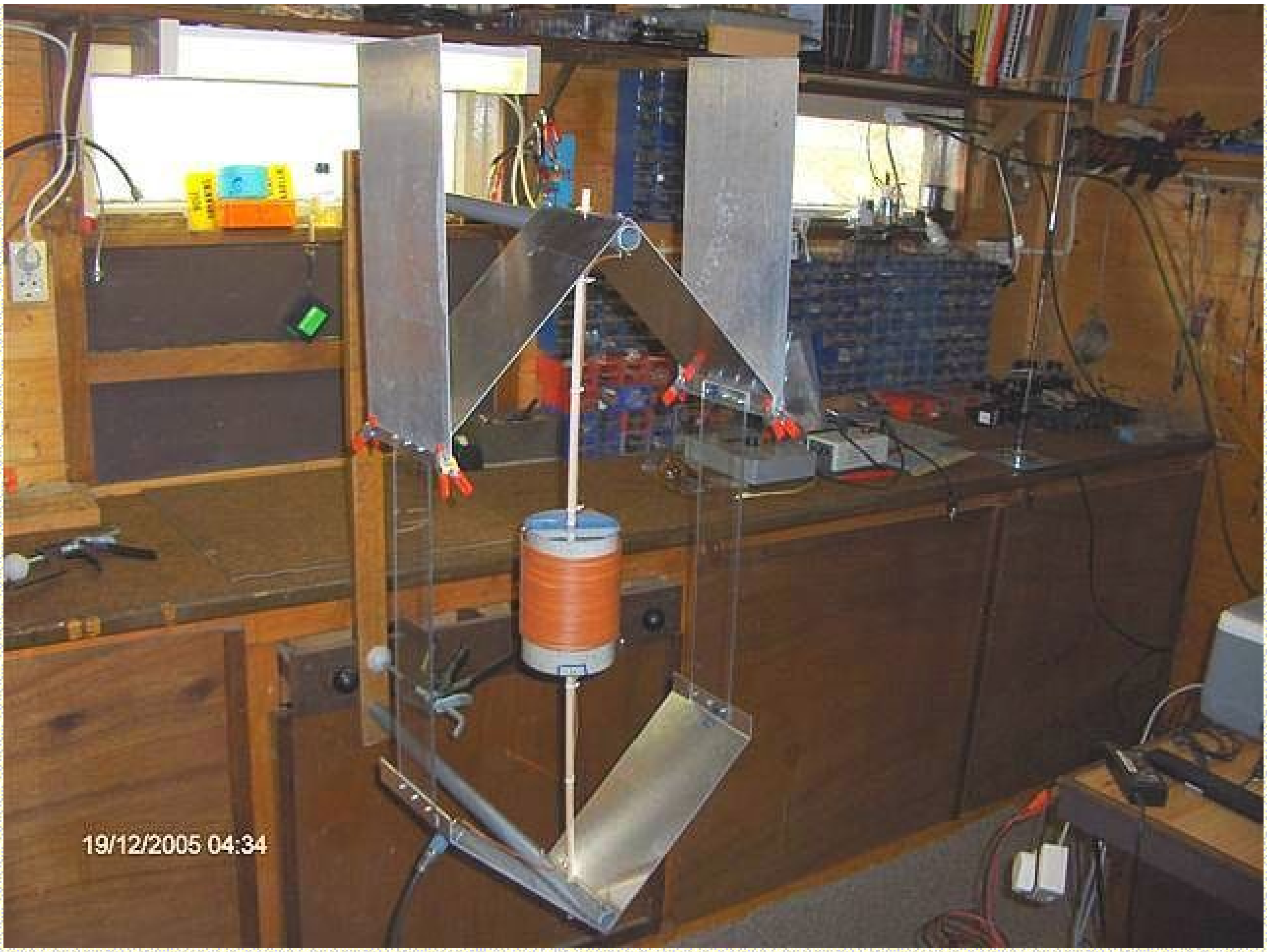
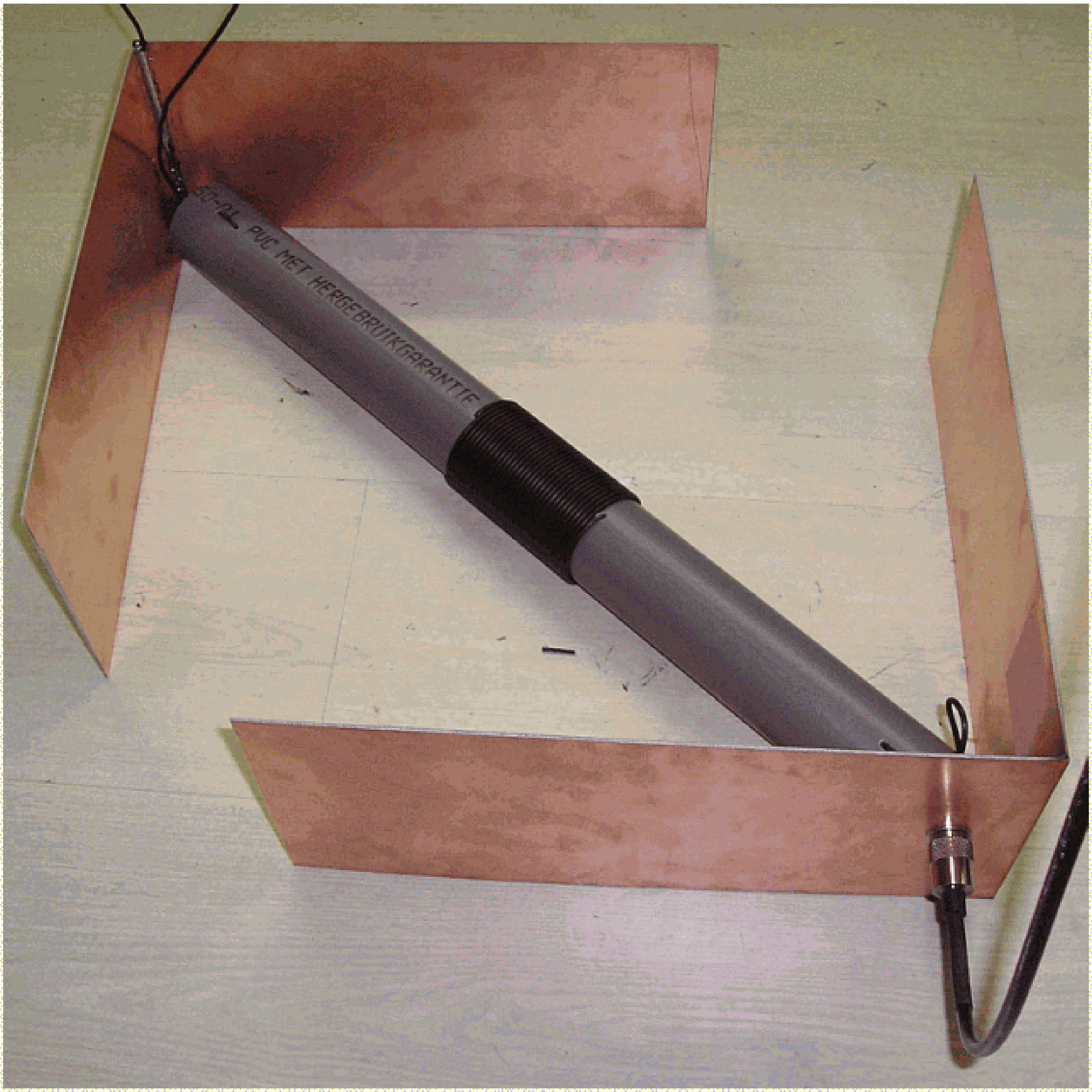


The roof capacity was increased with side plates.

PA1AMS's 40 M ISOTRON



PA1AMS's Isotron antenna.

Hans PA1AMS has also used 32 windings (fig ») but then on a 5 cm PVC pipe. Pipe length is 71 cm × 32 mm (washbasin drain).

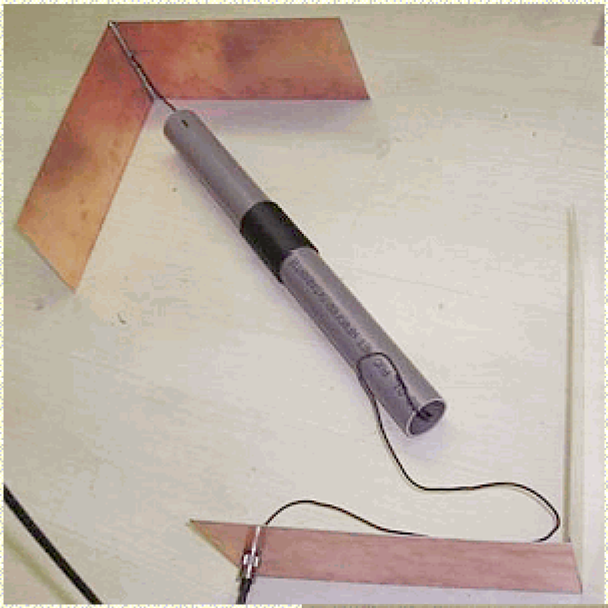
Plates are double-sided circuit board 14 × 33 cm. As can be seen, the coil was made interchangeable by locking it with M4 bolts.

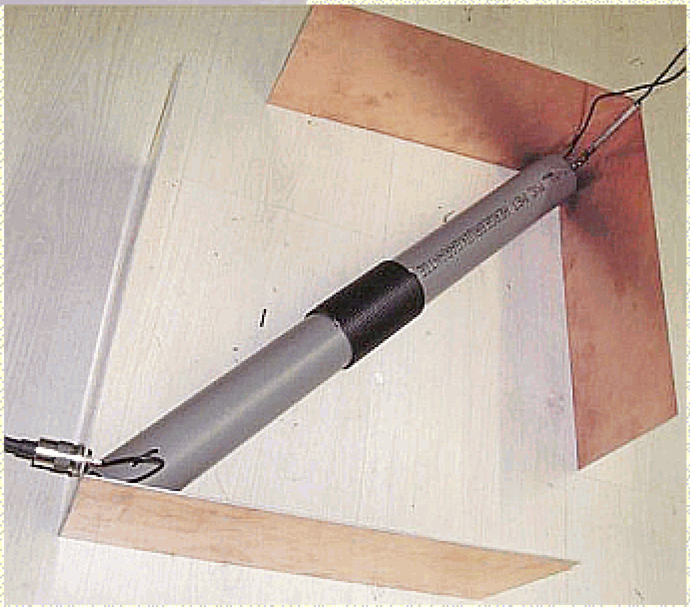
Connection with coil goes with aluminum strip 15 mm.

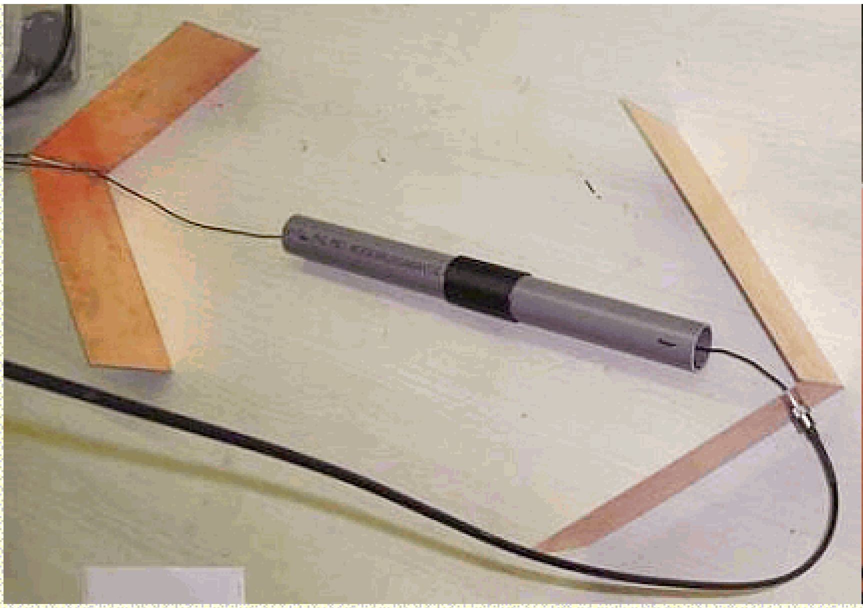
Without tuner the SWR = 1.1 was at 40 m.

In practice PA1AMS was not impressed by the operation, even during experiments at a campsite. It was a nice project but he prefers a magnetic loop for reception. There are now also a number of made.

There is a difference with PAUNT's implementation. The connection of the coax cable is at the bottom in the tip. He wondered why Nico's design on the photo shows an asymmetrical placement of the plug.








Different ways of feeding through PA1AMS.

K9HKS'S JUDGMENT ABOUT THE ISOTRON 80

In the magazine Amateur Radio Today p. 44, K9HKS published an opinion about an ISOTRON 80 in April 1996. The most important points from his article have been translated here.

The manufacturer of ISOTRON 80 has asked me to rate his product in comparison with the antennae that I use at home. Frankly, I had seen several advertisements and I thought that they were strange antennae, too small to be effective and only suitable for a flat or a car or camper.

The first test was done indoors on the ground floor and the antenna was connected to my TS-440S by about 3 m coaxial cable. What a surprise: with an antenna that looked more like a 2 m spotlight, the stations reached 80 m well. Then the antenna was mounted on a 6 m mast in the backyard. According to the manual, there would be no resonance at the end of our 80 m band without tuning and that was correct because the SWR was 1 - 1.1 at 3,940 MHz and given the conditions the signals were not bad that afternoon. I could work with several stations with 58, 59 and 57 reports. I was curious how that would be later in the evening if I had a connection with my regular counter stations that were accustomed to a certain strength of my broadcasts. What turned out: nobody seemed to notice that I was not sending my dipole! When I told them what I was working with, they found that unbelievable because their first thought about an isotron was identical to mine when I saw such an antenna for the first time. During reception when switching from isotron to dipole, it appeared that the first antenna produced less local interference. When the transmission was always switched over for a longer period of time, the dipole was 1 to 2 S points stronger than the isotron for some time. But it also occurred that for some time both signals were the same while the dipole was suspended 5 m higher. It was time to do tests at a higher altitude and a day later the isotron with a new piece of coaxial cable was already in the 17 m high mast. Now a real test could begin! When I told them what I was

working with, they thought that was incredible because their first thought about an isotron was identical to mine when I saw such an antenna for the first time. During reception when switching from isotron to dipole, it appeared that the first antenna produced less local interference. When the transmission was always switched over for a longer period of time, the dipole was 1 to 2 S points stronger than the isotron for some time. But it also occurred that for some time both signals were the same while the dipole was suspended 5 m higher. It was time to do tests at a higher altitude and a day later the isotron with a new piece of coaxial cable was already in the 17 m high mast. Now a real test could begin! When I told them what I was working with, they thought that was incredible because their first thought about an isotron was identical to mine when I saw such an antenna for the first time. During reception when switching from isotron to dipole, it appeared that the first antenna produced less local interference. When the transmission was always switched over for a longer period of time, the dipole was 1 to 2 S points stronger than the isotron for some time. But it also occurred that for some time both signals were the same while the dipole was suspended 5 m higher. It was time to do tests at a higher altitude and a day later the isotron with a new piece of coaxial cable was already in the 17 m high mast. Now a real test could begin!

In the shack I noticed that the resonance was shifted to 3,867 MHz with a SWR of 1 - 1.4 but with the built - in antenna tuner the entire 80 m band could be covered. Without ATU, the SWR = 2 at 3.843 and 3.893 MHz (bandwidth 50 kHz at SWR = 2).

I am still amazed at the performance of this antenna and that really exceeds my wildest expectations. Whenever I broke into all kinds of QSOs and compared the received reports with the now 7 m lower suspended dipole, the isotron was better. It also appeared that the antenna was rounded. During the period in the following weeks, I experienced that the antenna was performing more than I had ever expected. The best was a report of 59 $^{+}$ 30 while a friend who lives about 20 km away from me got only 59 $^{+}$ 15. Stations about 150 - 200 km away on the dipole 1 to 2 S points stronger but further on the isotron is better (at 80 m).

The tests speak for themselves and at this location I remove the dipole and an isotron becomes the antenna!

INFORMATION ABOUT ISOTRON ANTENNAS

PA1AMS and Tom Jansen have found the following links about isotron antennas on the internet.

http://f5ad.free.fr/Archives_liens_coupes/DL4SZ%20Antenne%20isotron.htm (lots of info!)

http://f5swn.free.fr/radio_ville2.html

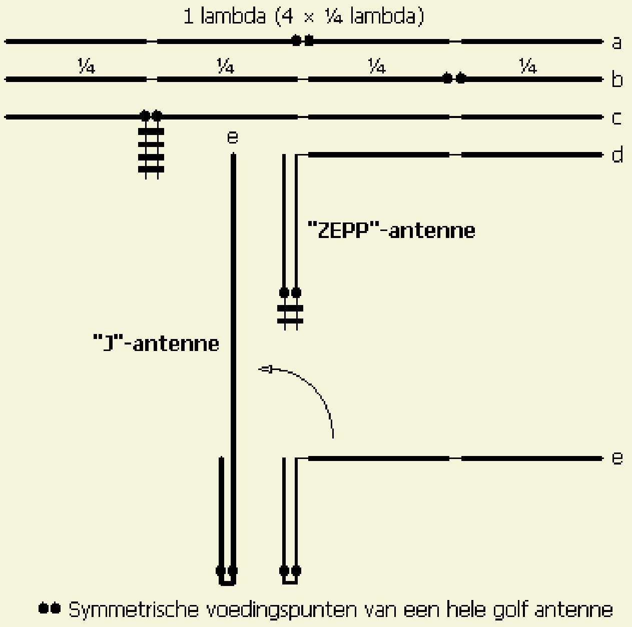
http://www.hari-ham.com/info/isotron.htm

http://www.isotronantennas.com/isomn80.pdf

http://www.isotronantennas.com/isomn40.pdf

J Antenna for 2m

OPERATION J ANTENNA



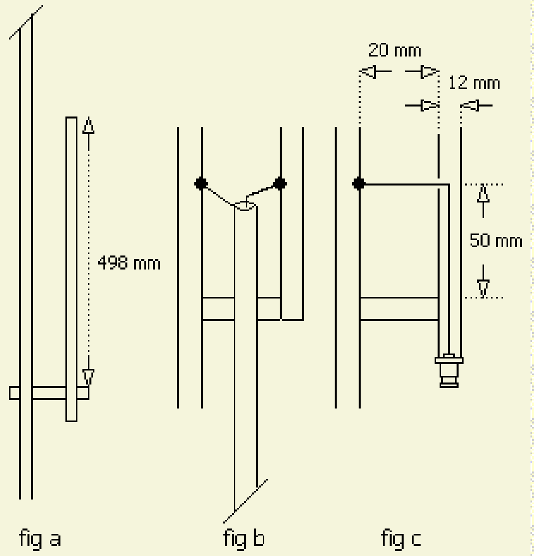
An J antenna (in fact a ZEPP antenna) can be considered as a whole wave (λ) radiator of which one dipole half (= ½ λ) is folded. Because in the latter case the conductors are very close to each other, they do not participate in the actual radiation. Symmetrical power supply of a 1 × λ antenna is possible in three places according to figures a, b and c (fig »). You can see in figure d that if a ½ λ part is folded, a symmetrical feeding point will still exist. Also when the folded part is onthe end is short-circuited, the ¼ λ stub thus formed can be fed symmetrically over its entire length. In the so-called "J" antenna, the feeding point is also symmetrical. Often, however, this antenna is fed with a coaxial cable and then a balun or mantle choke should be used. If one does not do this and, for example, applies a neon lamp as an indicator, then one sees that the current and voltage distribution is not symmetrical over the antenna. Without balun it does not matter how the coaxial cable is connected to the antenna.

FOOD

The waterproof version

The experimental version.

Many 2-m J antennas are being built worldwide from copper water pipes. The power supply is usually connected symmetrically (fig b) with an asymmetrical coaxial cable and it is then not so easy to make the system water-resistant.



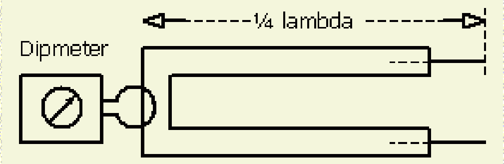
A method to prevent this is shown in Figure c. This can also be easily made with standard installation material and combined with the assembly of a coaxial plug.

In my construction, 12 mm copper water pipe was used with two associated T couplings. The drilling of a T coupling makes it possible to consist of an antenna and a standpipe in one piece. To solder the two couplings together, you need an approximately 18 mm long spacer. If you apply the 498 mm (inside) size of figure a, then the ¼ wave stub resonates exactly in the middle of the 2 m band at 145 MHz.

COAX CABLE RAYS

Often it is not pointed out that such an end-fed antenna without radians can result in a radiant coaxial cable ("fig"). If the antenna is mounted on a metal mast, this serves as "radial" and will greatly reduce the radiation of the cable. The mast takes over part of the radiation and that is forgotten when it comes to promoting a J-antenna (J-pole).

¼ λ STUB



If this antenna is assembled with different material, a stub must first be made separately, which is brought to the length of the belt with a dipper. Make the length of the stub (fig ») about 2 cm shorter than the calculated length and apply at the ends, eg with rubber bands, threaded ends that can be moved to change the total length of the stub. During the alignment procedure it is wise to monitor with a good receiver whether the scale of the dipmeter is correct. The construction can then be reconstructed with the radiator and the location of the adaptation can only be determined with a good UHF SWR meter.

If everything is correctly adjusted, the length of the coaxial cable will have no effect on the SWR and if one spins over the 2m band the SWR must change to the same degree with respect to the central frequency. If it is different then a point with low SWR can be found, but as soon as the power cable gets a different length it is already wrong with the SWR. The mistakes one makes a lot relate to:

- no real good SWR meter for 2 m used.

-reported length of the stub, which depends on the shortening factor by material and construction

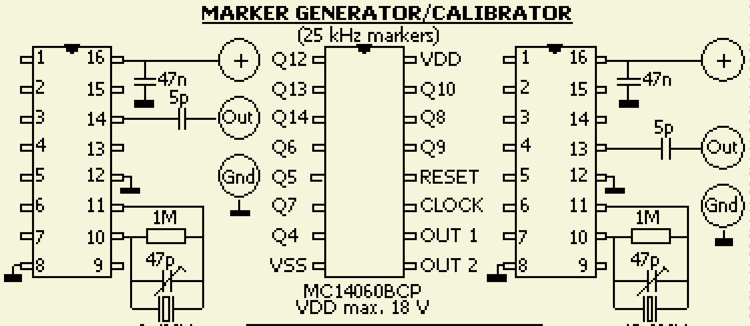
-Reasonable length of the radiator.

-not symmetrical feeding of the stub, with a coaxial cable a balun or matel flow filter is needed.

«Back AØFRI

MARKER GENERATOR OR CALIBRATOR

Much of the older transceivers can only rely on a linear mechanical scale that can be calibrated with a 100 kHz oscillator. Those circuit mainly works with a 100 kHz crystal. The marker points are rather far apart and it's not always easy to get "on frequency". Sometimes, the crystal respective doesn't oscillate or will not work 100% and at present a 100 kHz crystal is often unavailable.



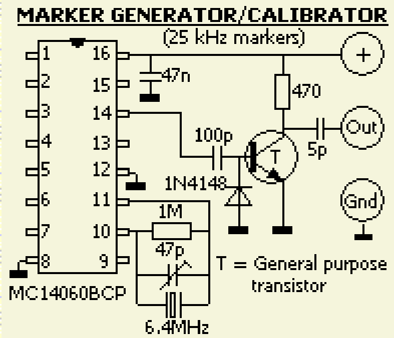
	Pin 4	Pin 6	Pin 14	Pin 13	Pin 5	
6.4MHz	100	50	25	12.5		kHz
12.8MHz		100	50	25	12.5	kHz

A replacement for an existing marker oscillator can be easily and cheaply build with modern components such as a MC14060BCP (or an equivalent type) and an inexpensive microprocessor crystal. The IC is a 14-stage binary ripple counter with an on-chip oscillator buffer.

This type of marker generators is nothing special. However, the circuit used here is very simple, differs from the original data sheet and (fig») has few components. All-in experiment showed a good functioning of the circuit and the beeps are also strong enough on the 2 m band. With a 6.4 MHz crystal and the internal oscillator, the generated frequency is divided further and creates marks of 12.5, 25, 50 and 100 kHz. See the table.

The frequency can be precisely tuned with a frequency counter to pin 9.

When used in a vintage 2 m transceiver it showed that a division to 12.5 kHz the marks were weaker than the beeps of a division for 25 kHz, while the 12.5 kHz marks can be observed.



A 12.8 MHz crystal from a scrapped PC did well in the circuit, but the 25 kHz raster signal should be taken from pin 13 (V9). More equal pulses can be obtained with an additional pulse amplifier as an IC or a general-purpose transistor. I have tested different types and all (e.g. BC547, C945) produced even good pulses in the 2 m band and strong beeps in the HF range.

All circuits were tested with a stabilised voltage of 9 V.

«Back PA0FRI

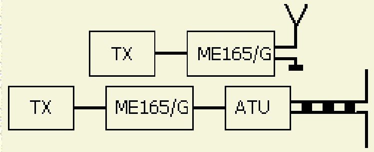
ME-165/G SWR-POWER METER 1.8–30 MHz

With internal dummy load, Watt-meter and quiet-tuning facility

27 jan 2013 With updated schematic and added text.

SWR-POWER METER ME-165/G

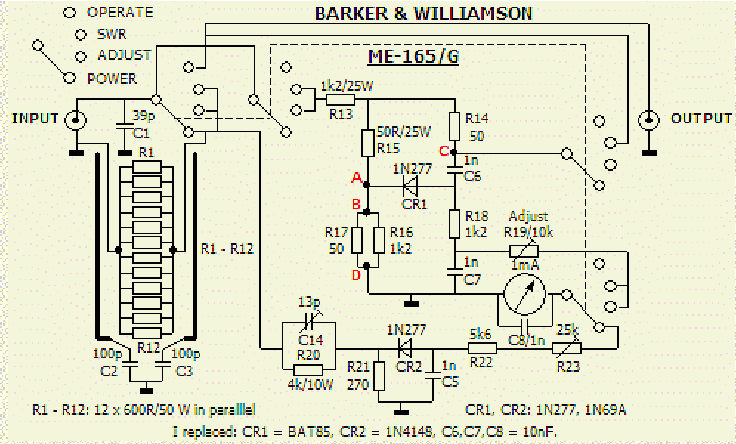
The ME-165/G is manufactured by Barker & Williamson, Inc. (SWR-POWER METER ME-165/G, Radalab (STANDING WAVE RATIO-POWER METER ME165/G) and others as matching unit designed for use with T-368 400 W transmitter. This combination dummy load/SWR/power meter is an especially useful accessory to have for a ham.



Left: BARKER & WILLIAMSON's ME-165/G, right: RADALAB's ME165/G

The meters show something different and at Radalab's front the text is printed and at B & W's is grooved and filled with paint.

ME-165/G



The matching unit is provided with:

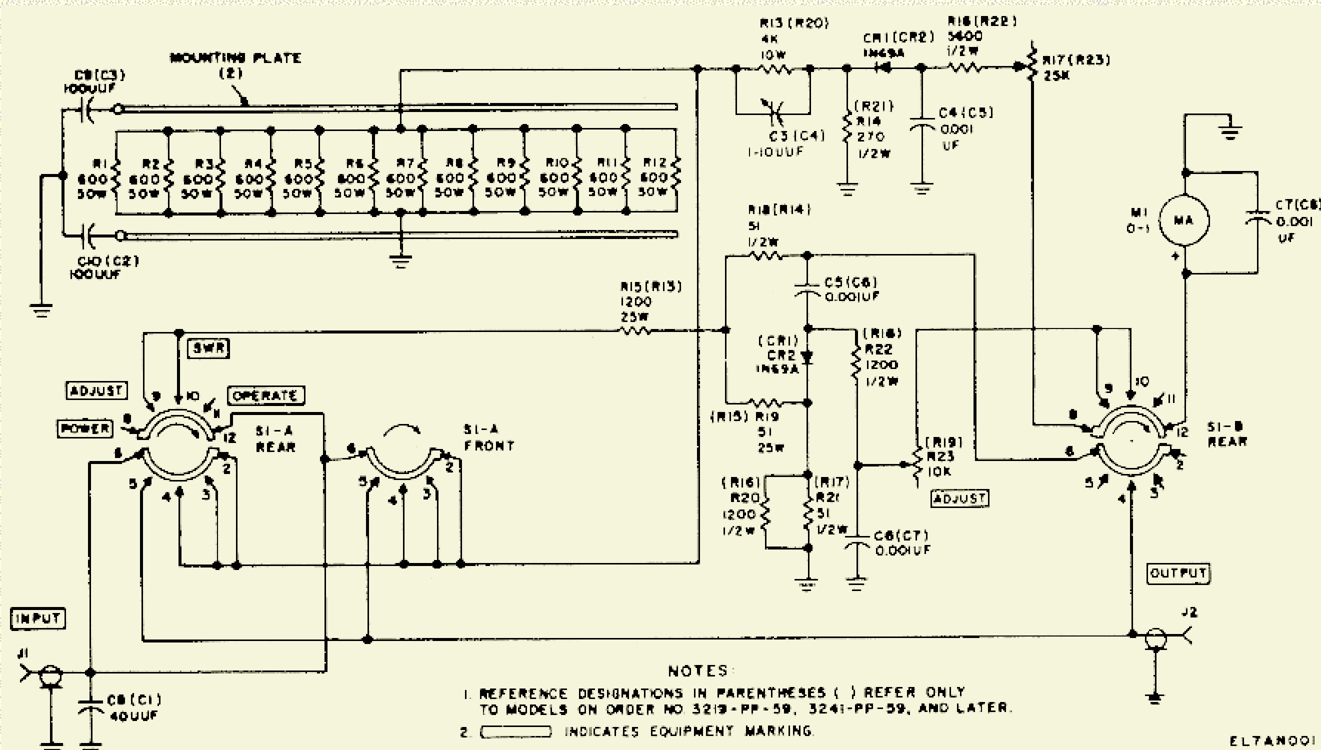
1. Internal dummy load 50 Ω/600 W

2. Power-meter ≤ 600 W

3. SWR-meter

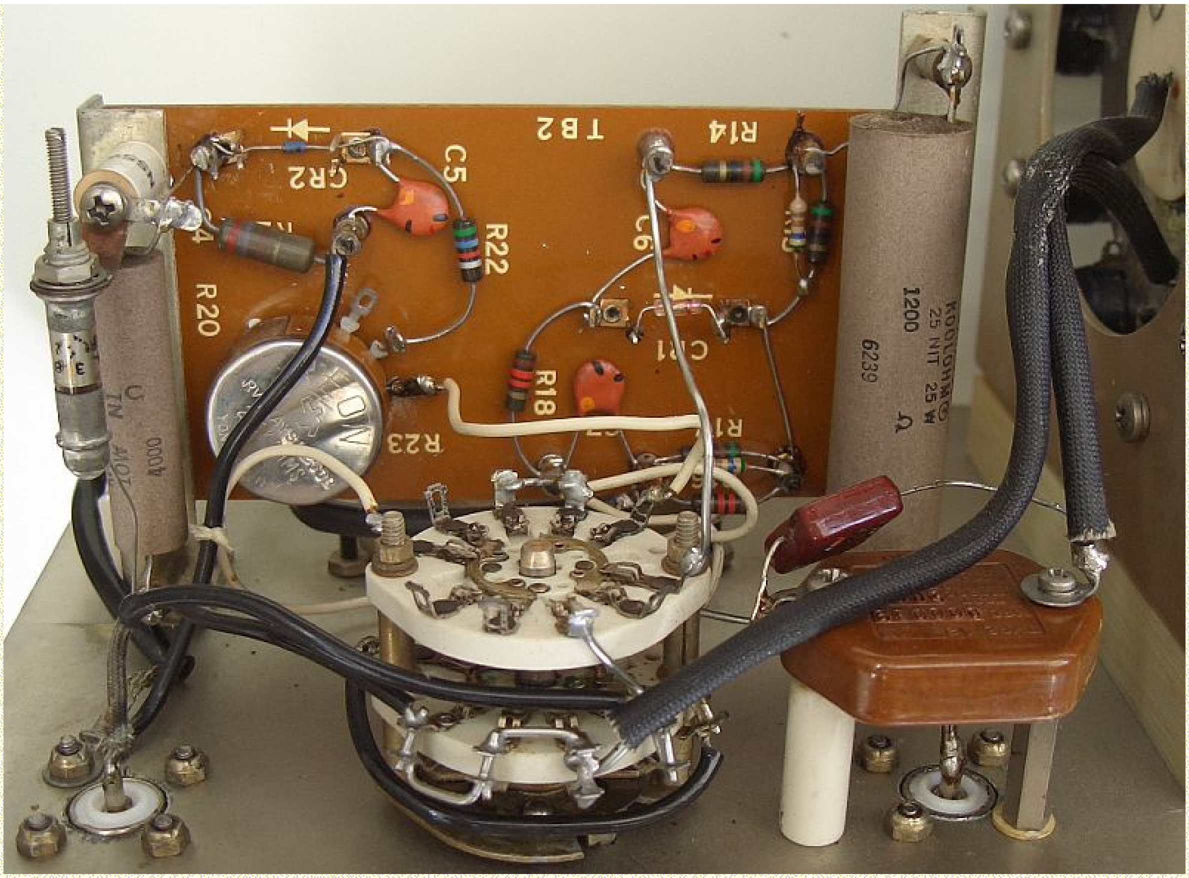
4. Quiet tuning facility

This schematic was drawn with my ME-165G PCB as an example because the original diagram was not in my possession.



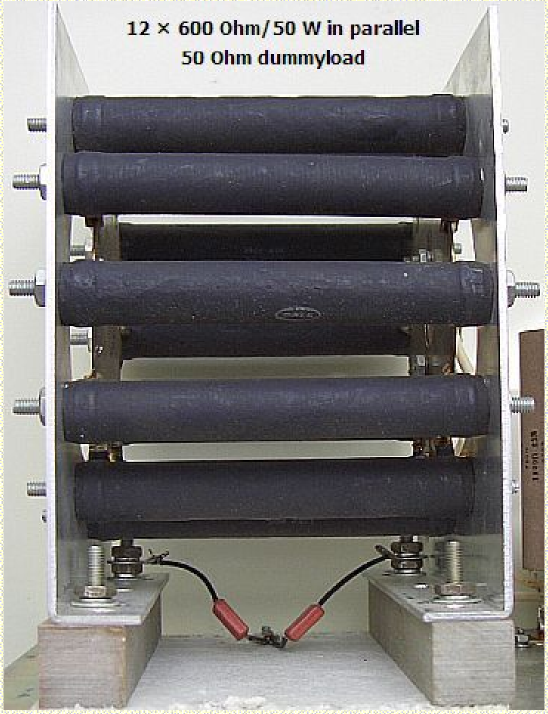
Later ON4FVQ emailed a copy of U.S. ARMY Technical Manual TM 11-6625-333-15 March 1971 that contained the showed schematic.

The 1N69A diodes and the numbering of the components are different than on my PCB board, but in the "military" diagram it is shown in brackets.



Wiring detail ME-165/G

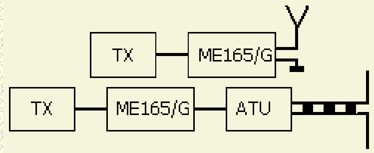
DUMMY-LOAD 50 Ω

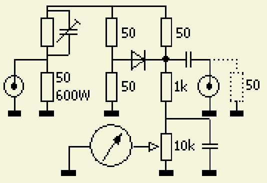


The dummy load (fig») used 12 × 600 Ω/50 W non-inductive 5% resistors in parallel to provide a 50 Ω/600 W load with a SWR of 1.5 or less up to 30 MHz. However when dissipating power in excess of 250 W limit the operation to intermitting on-off periods. Do not apply 600 W power for longer than 10 minutes. The matching unit can be damaged by the great amount of heat generated. For longer periods a ducted airflow should be used for the dummy load.

Stray inductances are tuned out with three capacitors at the input and at the ends of the paralleled resistors.

PRINCIPLE OF QUIET TUNING





Principle of ME-165/G

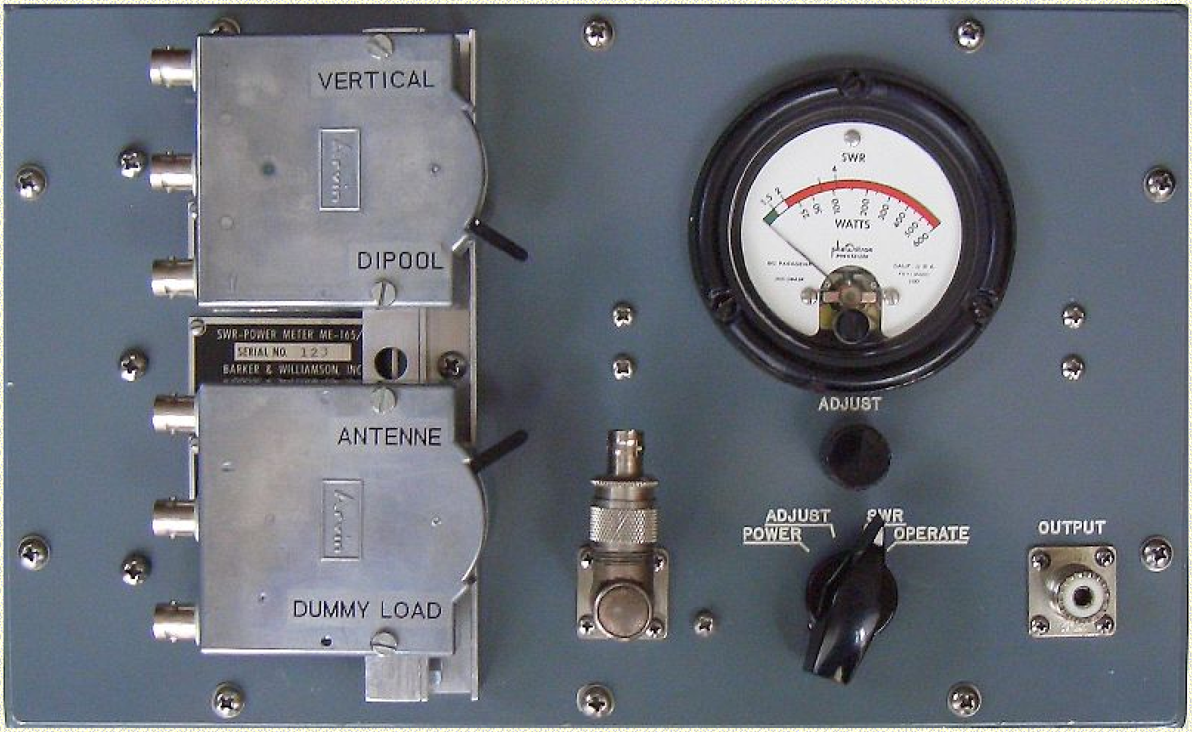
In a quiet tuning system («fig) the full power is dissipated in a non-inductive resistor and a minor part of the power is used for a bridge circuit that permits direct readings of the SWR between the transmitter and its load (Antenna or tuning unit). If one is matching his ATU or antenna the low power output will not be noticed by another ham. With the control switch in the SWR position the ME-165/G's output is only 50–100 mW and the transmitter is loaded with a perfect 50 Ω match. 1N277 can replace a defect diode.

Note In my unit were CR1 and CR2 defective or not in order. In the absence of original components I replaced CR1 by a germanium diode and CR2 by a 1N4148. With the last I obtained a pretty good accurate Wattmeter scale.

After years the SWR meter readings becomes unstable. After a survey of about two days, the cause was detected in the meter. The terminals operate as diodes by oxidation. After cleaning for security C8 was replaced with a 10 nF capacitor. During the research I had already replaced C6 and C7 with 10 nF.

As an experiment germanium diode CR1 was removed and a Schottky BAT85 installed. A sensitive measurement occurs with a more accurate SWR = 1 as result. It will be clear that the device is not removed!

MATCHING SEQUENCE FOR LOW SWR



Two switches added.

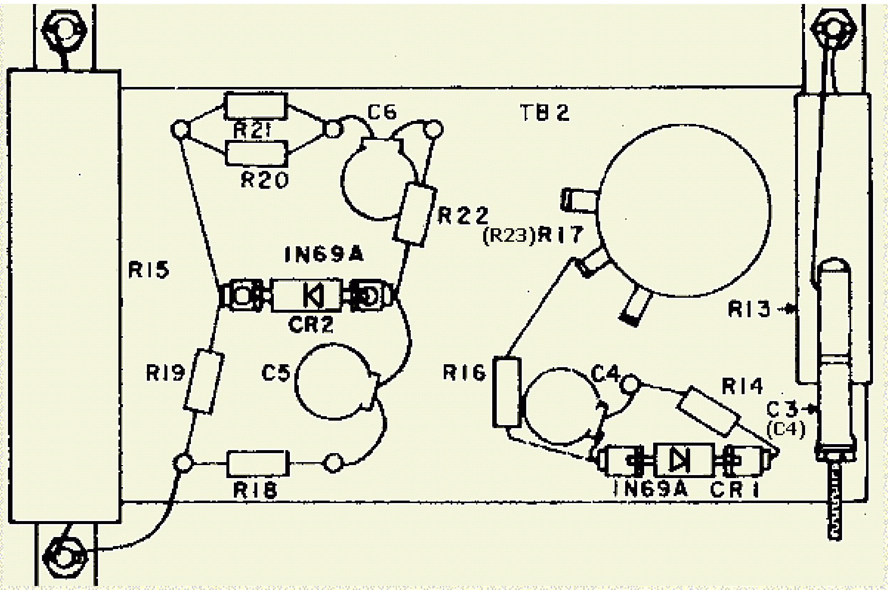
Set the ME-165/G function switch to POWER. Adjust the transmitter for cw operation. Connects transmitting power to the unit and power output is indicated on the meter.

Set the switch to the ADJUST position and rotate the ADJUST control to obtain a full-scale meter reading. Do not keep the switch in that position any longer than necessary for meter adjustment.

Set the switch to the SWR position. The SWR between the transmitter and ATU or antenna may now be read and you may match your ATU for lowest SWR.

Finally set the switch to the OPERATE position and the transmitter output is connected directly to the load.

LINEARITY ADJUSTMENT



Adjustment is best done with a borrowed accurate in-line Wattmeter.

-Set the ME-165/G functions switch to POWER.

-Adjust the transmitter for CW operation at 1.8 MHz.

-Key the transmitter and compare the power indication on the ME-165/G with the power indication on the Wattmeter so that the indications should agree within 5%.

-If the ME-165/G power meter indication is not correct within 5%, adjust ME-165/G potentiometer R17 (R23) so that the power meter indicates the same power as the Wattmeter.

-Adjust the transmitter for CW operation at 28 MHz. Key the transmitter and compare the power indication on the ME-165/g with the power indication on the Wattmeter; the indications should agree within 5%.

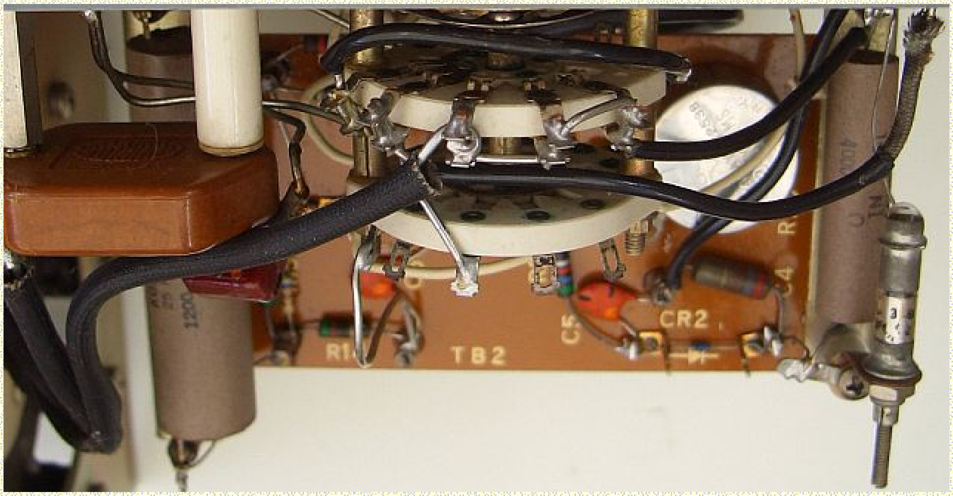
-If the ME-165/G power meter indication is not correct within 5 percent, adjust ME-65/G capacitor C3 (C4) so that the power meter indicates the same power as the Wattmeter.

-Repeat the procedures given above, as necessary, until the ME-165/G power meter indications are correct at both ends of the frequency range.

ACCURACY

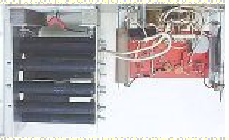
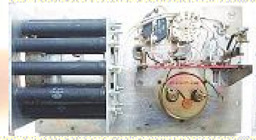
The ME-165/G must be recalibrate with R17 (R23) and C3 (C4) after any repairs or adjustments. If the power meter is well calibrated the accuracy of the scale is almost 5% that is better than most ham's SWR/PWR meters.

Calibration checks should be done with the front panel firmly pushed to the enclosure.



The SWR reading may not accurate due to the messy wiring from input to switch, from switch to dummy load and from switch to output. Replace the messy wiring by 50 Ω coax cable.

The null on 10 m can be improved when the two wires from switch to dummy load are bound together with tie-rap cable ties or plastic and waxed-linen lacing cords.



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Aircraft Frequencies

World Wide HF and VHF/UHF Aircraft Communications Listening

What do you need to get started listening to the world of monitoring Aircraft communications?

If you have a good quality VHF/UHF scanning receiver and a HF communications receiver that will tune from about 2mhz thru 30mhz with LSB/USB mode on the HF bands (shortwave radio) then you are all set to join in the excitement of DX'ing HF Aeronautical radio communications.!

If you just stumbled into this site and your looking for a good quality receiver for HF, then check out this page and look for the Sony ICF SW 7600GR. It is highly recommended for tuning the Hf aircraft band frequencies.

To monitor the VHF/UHF frequencies:
You will need a good quality scanner receiver for VHF UHF to monitor aircraft frequency bands over land or within line of sight of major air traffic control centers. You won't have a problem hearing airborn aircraft within your area. Remember that VHF / UHF frequencies are "line of sight". If the aircraft are beyond your horizon, you won't hear them due to their signals being blocked by the earth.
Excellent quality VHF/UHF scanners can be found from ScannerMaster.

A good outside antenna will also help your receiver to receive the signals much better. See the shortwave antenna projects on this site and build one for HF and also look on the antenna projects page (Antenna Design) on the left menu, for any antenna that can be built for the VHF bands and designed for the aircraft frequencies. Check out the simple projects. You'll save big bucks by doing it yourself! Most are simple to build using material from your local hardware store, Lowes, Home Depot, etc and since you will only be using them on receive only, no special test equipment will be needed. A good HF multi band project can be found here!

Who, what and when!

Aircraft communications from over the oceans can be very boring at times or very exciting! Along with the use of satellite communications, commercial and military aircraft use either the VHF/UHF frequencies when over or near land and switch to worldwide or nearly so, HF frequencies when over oceans and far beyond line of sight with land based ground stations.

They are not active all the time and are not always on the frequency that you are, so be patient and tune around the frequencies listed on this page.

The aeronautical voice communications stations and frequencies listed in the tables below are available to and utilized by the U.S. FAA Air Route Traffic Control Centers (ARTCCs) for air traffic control purposes.

The frequencies in use will depend upon the time of day or night and conditions which affect radio wave propagation especially on HF frequencies. Voice communications are handled on a single channel simplex basis (i.e., with the aircraft and the ground station using the same frequency for transmission and reception) unless otherwise noted in remarks.

The stations will remain on continuous watch for aircraft within their communication areas, and when practicable, will transfer this watch to another station when the aircraft reaches the limit of the communications area.

Stations listed below which are designated "FAA" are operated by the U.S. FAA Flight Service Stations. Stations designated "ARINC" are operated by Aeronautical Radio, Incorporated. Sections or frequencies highlighted in Green in the table below are usually long range and are usually transmitted in USB mode.
Other frequencies (VHF/UHF) are AM.

STATION	RADIO	TRANSMITTING	REMARKS

AND OPERATING AGENCY	CALL	FREQUENCIES	Freqencies with decimal point are (Mhz) Others are khz
HONOLULU (FAA)	Honolulu Radio	122.6 122.2 **#121.5 MHz**	#Emergency. Frequency 122.1 also available for receiving only.
	Volmet	2863 6679 8828 13282 kHz	Broadcasts at H+00-05 and H+30-35; Aerodrome Forecasts, Honolulu, Hilo, Agana, Honolulu. SIGMET. Hourly Report, Honolulu, Hilo, Kahului, Agana, Honolulu.
			Broadcasts at H+05-10 and H+35-40; Hourly Reports, San Francisco, Los Angeles, Seattle, Portland, Sacramento, Ontario, Las Vegas. SIGMET. Aerodrome Forecasts, San Francisco, Seattle, Los Angeles.
			Broadcasts at H+25-30 and H+55-60; Hourly Reports, Anchorage, Elmendorf, Fairbanks, Cold Bay, King Salmon, Vancouver. SIGMET. Aerodrome Forecasts, Anchorage, Fairbanks, Cold Bay, Vancouver.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
MIAMI (FAA)	Miami Radio	126.7 118.4 126.9 122.2 122.4 122.75 123.65 127.9 MHz	Local and Short Range.
		#121.5MHz	#Emergency.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
NEW YORK (FAA)	New York Radio (Volmet)	3485* 6604 10051 13270* kHz	*3485 Volmet broadcasts from 1 hour after sunset to 1 hour before sunrise.
			*13270 Volmet broadcasts from 1 hour before sunrise to 1 hour after sunset.
			Broadcasts at H+00-05; Aerodrome Forecasts, Detroit, Chicago, Cleveland. Hourly Reports, Detroit, Chicago, Cleveland, Niagara Falls, Milwaukee, Indianapolis.
			Broadcasts at H+05-10; SIGMET, (Oceanic-New York). Aerodrome Forecasts, Bangor, Pittsburgh, Charlotte. Hourly Reports, Bangor, Pittsburgh, Windsor Locks, St. Louis, Charlotte, Minneapolis.
			Broadcasts at H+10-15; Aerodrome Forecasts, New York, Newark, Boston. Hourly reports, New York, Newark, Boston, Baltimore, Philadelphia, Washington.
			Broadcasts at H+15-20; SIGMET (Oceanic-Miami/San Juan). Aerodrome Forecasts, Bermuda, Miami, Atlanta. Hourly Reports, Bermuda, Miami, Nassau, Freeport, Tampa,West Palm Beach, Atlanta.
			Broadcasts at H+30-35; Aerodrome Forecasts, Niagara Falls, Milwaukee, Indianapolis. Hourly Reports Detroit, Chicago, Cleveland, Niagara Falls, Milwaukee, Indianapolis.
			Broadcasts at H+35-40; SIGMET (Oceanic-New York). Aerodrome Forecasts, Windsor Locks, St. Louis. Hourly Reports, Bangor, Pittsburgh, Windsor Locks, St. Louis, Charlotte. Minneapolis.
			Broadcasts at H+40-45; Aerodrome Forecasts, Baltimore, Philadelphia, Washington. Hourly Reports, New York, Newark, Boston, Baltimore, Philadelphia, Washington.
			Juan). Aerodrome Forecasts, Nassau, Freeport. Hourly Reports, Bermuda, Miami, Nassau, Freeport, Tampa, West Palm Beach, Atlanta.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
NEW YORK (ARINC)	New York	3016 5598 8906 13306 17946 21964 kHz	North Atlantic Family A Network.
		2962 6628 8825 11309	North Atlantic Family E Network.

		13354 17952 kHz	
		2887 3455 5550 6577 8846 11396 kHz	Caribbean Family A Network.
		5520 6586 8918 11330 13297 17907 kHz	Caribbean Family B Network.
		3494 6640 8933 11342 13330 17925 kHz	Long Distance Operations Control (LDOC) Service (phone-patch). Communications are limited to operational control matters only. Public correspondence (personal messages) to/from crew or passengers can not be accepted. NOTE: New York ARINC can also provide HF communications over South America on these LDOC frequencies through their remote site located in Santa Cruz, Bolivia.
		129.90 MHz	Extended range VHF. Coverage area includes Canadian Maritime Provinces, and oceanic routes to Bermuda and the Caribbean, from Boston, New York and Washington areas to approximately 250 nautical miles from the east coast.
		130.7 MHz	Extended range VHF. Full period service is provided within most of the Gulf of Mexico. Also on routes between Miami and San Juan to a distance of approximately 250 nautical miles from the Florida coast and within approximately 250 nautical miles of San Juan. NOTE: New York ARINC also provides VHF communications over the Northern two-thirds of Mexico on 130.7 MHz for FAR Part 121.99 compliance.
		436623* 631-244-2492	Aircraft operating within the New York Oceanic FIR. *NOTE: This satellite Voice Air/Ground calling number is available to call ARINC and will be recognized and converted by all Ground Earth Station (GES) service providers to the appropriate Public Service Telephone Network (PTSN) or direct dial number for this communications center.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
SAN FRANCISCO (ARINC)	San Francisco	3413 3452 5574 6673 8843 10057 13354 kHz	Central East Pacific One Network
		2869 5547 11282 13288 21964 kHz	Central East Pacific Two Network
		2998 4666 6532 8903 11384 13300 17904 21985 kHz	Central West Pacific Network
		3467 5643 8867 13261 17904 kHz	South Pacific Network
		2932 5628 5667 6655 8915 8951 10048 11330 13273 13339	North Pacific Network

		17946 21925 kHz	
		3494 6640 11342 13348 17925 21964	Long Distance Operations Control (LDOC) Service (phone-patch). Communications are limited to operational control matters only. Public correspondence (personal messages)to/from crew or passengers can not be accepted. NOTE: San Francisco ARINC can also provide HF communications along the polar routes on these LDOC frequencies through their remote site located at Barrow, Alaska.
		131.95 MHz	Extended range VHF. Coverage area includes area surrounding the Hawaiian Islands and along the tracks from HNL to the mainland. Coverage extends out approximately 250NM from Hawaii and from the West coast.
		129.40 MHz	For en route communications for aircraft operating on Seattle/Anchorage/Routes.
		436625* 925-371-3920	Aircraft operating within the Oakland and Anchorage Oceanic FIRs. *Note: This satellite Voice Air/Ground calling number is available to call ARINC and will be recognized and converted by all Ground Earth Station (GES) service providers to the appropriate Public Service Telephone Network (PTSN) or direct dial number for this communications center.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
OAKLAND (FAA)	Oakland Radio	122.5 122.2 #121.5 MHz	#Emergency.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
SAN JUAN P.R. (FAA)	San Juan Radio	#121.5 122.2 126.7 123.65 #243.0 255.4 114.0 113.5 108.2 108.6 109.0 110.6 MHz	Unscheduled broadcasts H+00, H+15, H+30 and H+45 as appropriate, for Weather and Military Activity Advisories, on 110.6, 109.0, 108.6, 108.2, 113.5, and 114.0 MHz. #Emergency. For frequencies 114.0, 113.5, 108.2 and 109.0 MHz use 122.1 MHz for transmissions to San Juan Radio. For frequency 108.6 use 123.6 MHz.

Source of table information: *The FAA (Federal Aviation Administration)* Sept, 2006

AirCraft Frequency listing by State! Click Here! (You will leave this website)

Military Long Range Aeronautical Frequencies
U.S. ARMED FORCES GLOBAL HIGH FREQUENCY SYSTEM IS NOW CALLED
The High Frequency Global Communications System (HF-GCS).

The High Frequency Global Communications System is a network ofsingle sidebandshortwavetransmitters of the United States Air Force which is used to communicate with aircraft in flight, ground stations and some United States Navy surface assets. All worldwide receiving and transmitting sites in the HF-GCS system are remotely controlled fromAndrews AFB.

PUBLISHED FREQUENCY LISTING - HFGCS stations operate on “core" frequencies to provide increased "Global" coverage. The published frequency listing does not reflect complete system frequency authorizations. These published frequencies will be used for initial contact, EAM broadcasts, and short-term C2 phone patch and message delivery. Other extended or special services will be moved to each station’s available "discrete" frequencies.

You may hear highly encrypted or coded voice transmissions at times that make no sense whatsoever. Just be patient. Military and national security at work!

HF-GCS stations tend to operate in the aviation bands clustered around 5, 8 and 11/12 MHz, although other frequencies are in use.

The primary HF-GCS voice frequencies are 4724.0 KHz, 6739.0 KHz, 8992.0 KHz, 11175.0 KHz, 13200.0 KHz and 15016.0 KHz.
Primary HFGCS Frequencies 24 Hours: 8992 and 11175
Back up HFGCS Frequencies Day: 13200 15016
Back up HFGCS Frequencies Night: 4724 6739

In addition to the HF-GCS, U.S. aircraft frequently useMilitary Affiliate Radio System (MARS) HF stations (13927.0 KHz) and Canadian Forces HF stations (11232.0 KHz) to relay messages.

Although transmissions are often single sideband, the use of theALE , a type of digital transmission mode, is more and more common.

HF-GCS complements the use of satellite communications, and digital modes between aircraft and ground stations.

Stations of the HF-GCS Network

Andersen Global, Andersen Air Force Base, Guam Island

Andrews Global, Andrews Air Force Base, Maryland USA

Ascension Global, RAF Ascension Island, Atlantic Ocean

Croughton Global, RAF Croughton, United Kingdom

Diego Garcia Global, Diego GarciaNaval Station, Indian Ocean

Elmendorf Global, Elmendorf Air Force Base, Alaska

Hickam Global, Hickam Air Force Base, Hawaii

Keflavík Global, Keflavík NAS, Iceland

Lajes Global, Lajes Air Base, Azores

McClellan Global (aka West Coast Global), McClellan Air Force Base, California

Offutt Global, Offutt AFB, Nebraska

Puerto Rico Global,Salinas, Puerto Rico

Sigonella Global, Naval Air Station Sigonella, Sicily, Italy

Yokota Global, Yokota Air Base, Japan

Closed Stations

Thule AFB,Greenland USB Voice

The table below lists some common frequencies presenty in use.
Remember to tune around these frequencies also.
(All frequencies below in KHz. To convert to mhz, count from right hand side of number 3 places to left and add decimal)

USAF Bases such as Andrews, Edwards, McClellan,
Offutt, Ascension, Hickam, Thule, Elmendorf, etc.
can be heard with worldwide phone patches, Emergency Action
Messages, general traffic, etc on or near these frequencies and in the
table below:

4742, 6712, 6739, 8992, 11175, 11244, 13200, 15016

Freq-USB	Description or location
4.7090	Sigonella
4.7240	Andrews, Ascension, Elmendorf, Guam, Hickam, Lejes, Offutt, Salinas, Thule, Yokota
6.7120	Andrews, Ascension, Guam, Lajes
6.7240	Sigonella
6.7390	Ascension, Elmendorf, Guam, Hickam, Salinas, Offutt, Thule, Yokota
8.9920	Andrews, Ascension, Elmendorf, Guam, Hickam, Offutt, Salinas, Thule, Yokota
9.0070	Sigonella
9.0250	Lejes
10.7800	AF Eastern Test Range (Backup for Ascension), Cape Canaveral, Antigua, Ascension, Maui
11.1750	Andrews, Ascension, Elmendorf, Guam, Hickam, Salinas, Offutt, Thule, Yokota
11.1810	Lajes
11.2710	Andrews, Ascension, Elmendorf, Guam, Hickam, Lejes, Offutt, Salinas, Thule, Yokota
13.2120	Lajes
15.0160	Andrews, Ascension, Elmendorf, Guam, Hickam, Lajes, Offutt, Salinas, Thule, Yokota
15.0380	Sigonella
20.3900	AF Eastern Test Range (Backup for Ascension), Cape Canaveral, Antigua, Ascension, Maui

Aeronautical Mobile HF Bands (Khz) Commercial Aircraft

2850-3155 kHz **6525-6765khz**
3400-3500 **8815-9040**
4650-4750 **10005-10100**
5450-5730 **13200-13360**
15010-15100

Note: Military aircraft can be heard on some of these bands.

We welcome any corrections you may have to these frequencies!
Email us n4ujw at hamuniverse.com

Installing the X-Lock-3 in the Drake TR-7

Pete Juliano, N6QW radioguy90@hotmail.com

I have had excellent success in the use of the Cumbria Designs X-Lock products. The first installation was in a Ten Tec Corsair I which employed the X- Lock-2 and that was done in late 2011. I have since sold the Corsair and the next candidate was a Drake TR-7 where I simply moved the X-Lock-2 from the Corsair to the TR-7. That second install too was successful. The Cumbria Designs website featured an X-Lock-2 installation in TR-7, which was done by Ron, WD8SBB. In addition I also found an Internet reference to a similar X-Lock-2 installation by Marinos, SV9RDU. So between the two articles much of the ground had been plowed. I used the SV9RDU interface design from the X-Lock to the TR-7, which differs slightly from that of WD8SBB.

I was so pleased with the TR-7/X-Lock-2 combination that I purchased another TR-7 and the newest version, the X-Lock-3. The purpose of this short paper is to describe what is needed to install the X-Lock-3 in the TR-7. There is a physical difference in the size of the PC Boards which requires adapting the X-Lock-3 boards so that two convenient mounting holes on the underside of the TR-7 chassis can be used to anchor the PC-Board.

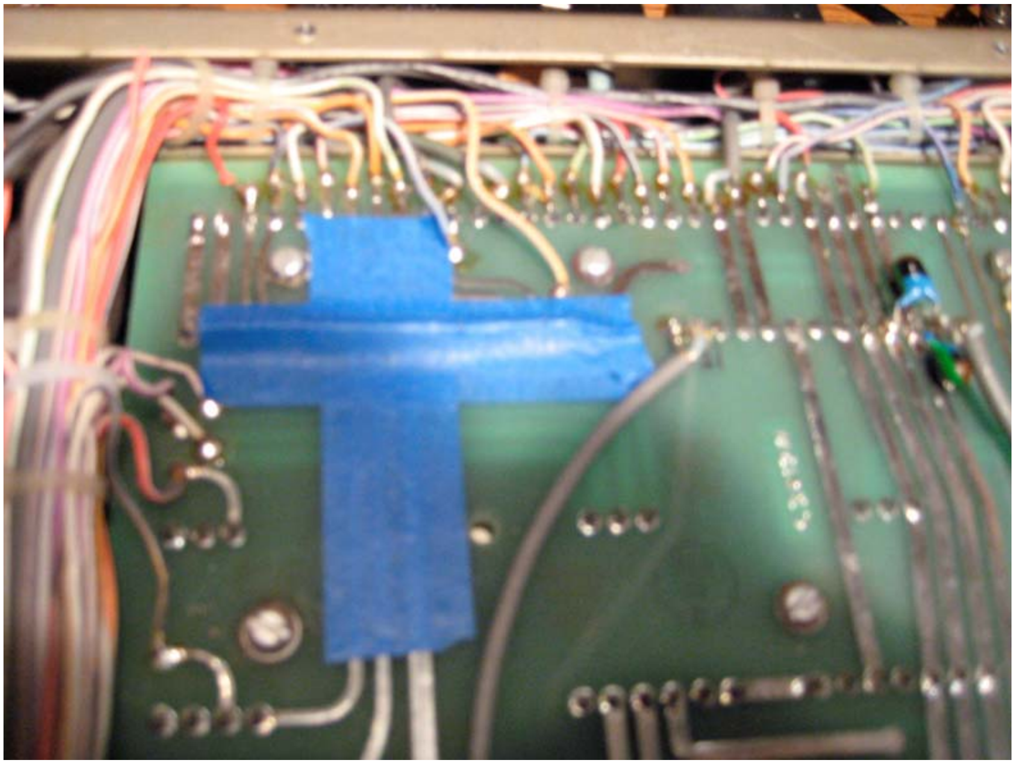
As luck would have it, the mounting holes in the X-Lock-2 board have the same exact spacing as the two screws which anchor the TR-7 Motherboard to the daughter board cage assembly. In the first TR-7 install I simply found longer 4-40 screws and used a 6-32 nut as a spacer and called it installed. Mario used a similar approach and modified some ring type crimp on connectors, which were bent at a right angle. The ring part is screwed down on the board using the original 4-40 screws and the vertical portions are fitted into two of the four mounting hole and soldered in place. Ron mounted his board in another location.

But alas the holes in the X-Lock-3 do not align with the mounting holes in the Motherboard. So at first I thought I would need to use the SV9RDU approach. However in my approach I used #4 solder lugs, which were bent in a “Z” shape so that the large hole is fastened to the chassis using the original 4-40 screws. By using ¼ inch long 2-56 bolts and nuts passed through the smaller hole this arrangement now attaches the PC Board to the TR-7. I was very pleased that it resulted in a very solid mechanical

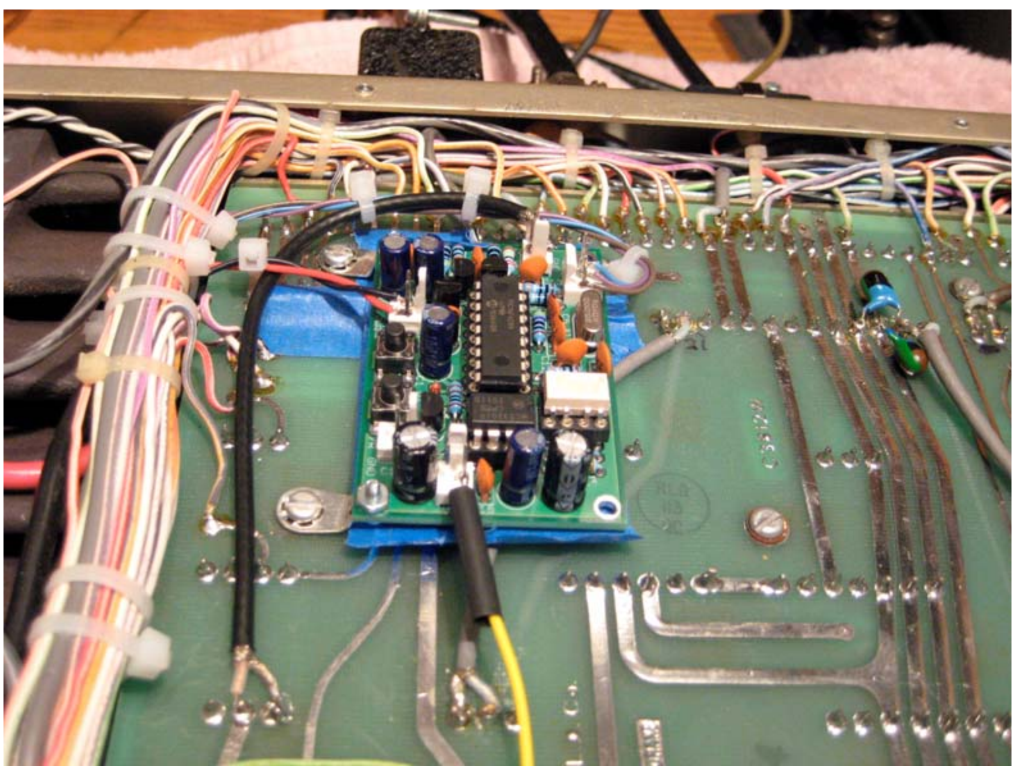
installation. For the tri-color LED I reversed the color so that RED is lock, versus the Green, and installed the LED in the holder where it normally would have the “Fixed light”. I installed a 3-pin header on the end of the cable that connects with the LED and installed a 3-pin plug on the LED. This is so if I have to make any adjustments to the X-Lock-3 I can simply unplug it from the end of the cable and plug it into the circuit board.

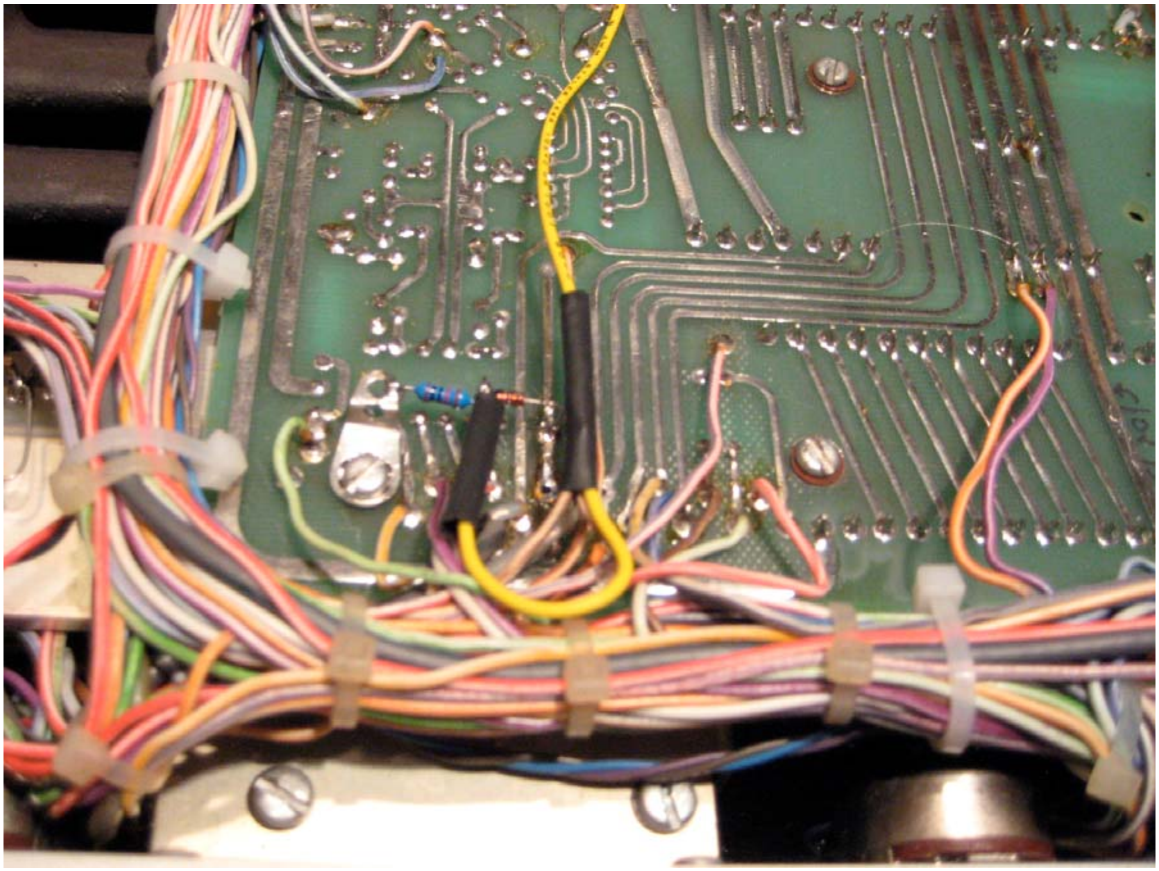
Shown below are the details of the installation.

The #4 solder lug is bent into a “Z” shape using a pair of needle nose pliers. For attachment to the PC board, ¼ inch long 2-56 screws are used. This forms a very stout mechanical connection.



I used 3M masking tape to provide a barrier so the PC Board would not short to the Motherboard traces.





As a final comment on the effectiveness of this addition, I noted that when using PTT that the “Lock” light would flicker briefly upon the “break” action of the relay. The TR-7 display would not change frequency but there was that brief “flicker.” I put a frequency counter on the PTO and observed that there was a brief change of about 80 Hz upon the “Break” action. This same situation is observed on both of my TR-7’s and was confirmed by Ron, WD8SSB on his TR-7 that has been fitted with an X-Lock-2. So this must be a common issue with the TR-7’s.

I also noted that the same condition (the flicker) exists with VOX that has been set up for a short VOX time. If however one lengthens the VOX delay then no flicker is observed and audibly the TR Relay sounds like a “soft break” versus a “clank sound” such as you would have with a quick VOX time constant. I am only guessing but with a longer delay on break there is some sort of exponential decay of the voltage being applied to the TR Relay. At first I thought there was a problem with the “snubbing diode”, a 1N4005 placed across the relay coil. But that is not the case since it is evident on at least three TR-7’s

I contacted Ron Taylor, G4GXO, the designer of the X-lock and he affirmed that any time the X-lock detects a frequency change the ‘wheels are put in motion” to correct for that frequency. So that is a bonus with the device that it is “on guard” to correct for any frequency deviation, even that caused by TR relays.

As a test of the X-Lock-3 capabilities I put the TR-7 on a specific frequency at 7:00PM one evening and left the radio powered on all night. The next morning at 7:00 AM I checked the TR-7 and it was on the same frequency as the evening before. I had run the same test with the other TR-7 and the X-Lock-2 and it was the same result. So the X-Lock is a great addition to the venerable TR-7 transceiver.

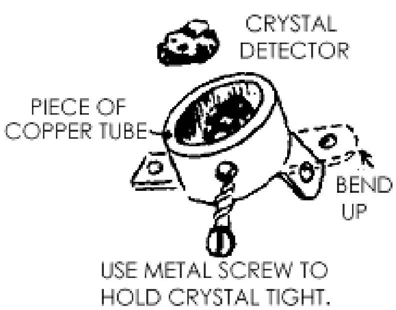
MENU
HOME
CATEGORIES
INDEX
WHAT'S NEW
FAQS
LINKS
CONTACT
SUBMIT
HELP SUPPORT
SITE HISTORY
CREDITS
AWARDS
LINK TO
DISCLAIMER

The crystal radio page

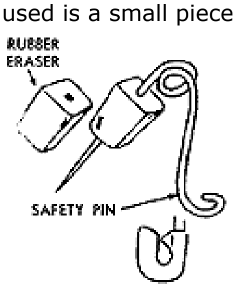
A crystal radio set is able to detect radio signals without a power supply. It works best if there is a transmitter within 25 miles (40 km) of the set. The antenna, a very long wire, picks up the waves and passes them through the set as electronic current, and then down to the ground. The set itself is a tuned circuit that can select a desired frequency from the many that are picked up by the antenna. The electric signals cannot be directly converted into sound because they vibrate back and forth too rapidly. The crystal (or diode) between the tuned circuit and the earphones allows the current to pass through in one direction only. The earphone contains a small solenoid and a thin metal plate. The current passing through the circuit and then through the diode causes the solenoid to move, which in turn moves the metal plate, whose vibrations create (faint) sound waves in the air.

A very simple crystal radio is not very selective, and if there are more than one nearby stations broadcasting near the same frequency, there will more than likely be some overlap, and you will hear two or more broadcasts at once. The solution is to add a tuner and a capacitor to the circuit. The coil length is what determines the frequency the circuit is tuned to. A simple tuner effectively changes the length of the coil by selecting how much of it is in the circuit. A capacitor (condenser) helps refine the tuning further.

A note about the crystal detector



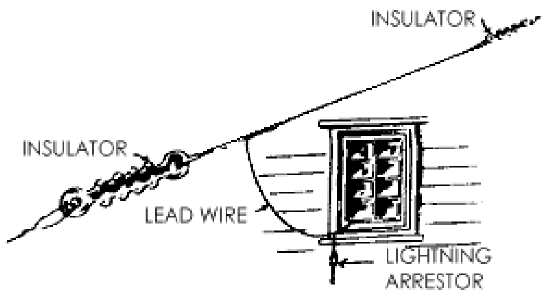
It is a fairly simple process to make a working radio using a modern diode for a detector. However, the reason these are called crystal sets is because the detector was originally a piece of crystal. You can still make your radio the authentic way with a crystal and cat's whisker. Detector stands are still manufactured, one good source being Antique Electronics Supply, 6221 S. Maple, Tempe, AZ 85283-2856 USA (phone 602-820-5411). A crystal detector includes a crystal, a cat's whisker, which is a special thin wire that contacts the crystal, and the stand that holds the components in place. The most common crystal used is a small piece of galena, which is fairly common, and can be found in many rock and hobby shops. The cat's whisker is most often composed of phosphor bronze. Once in circuit, the whisker can be moved about on the crystal's surface to find the most "sensitive" spot. The pressure of the whisker on the crystal is also adjustable. There are some other crystals that will work, so there is much room for experimentation with crystal fragments that you may already have. Also, it is not absolutely necessary to use a detector stand, and the cat's whisker can be improvised with a safety pin. Although it will be less selective and more difficult to adjust, it can be made to work quite satisfactorily. A small piece of rubber pencil eraser impaled on the safety pin helps to insulate it from your fingers while adjusting.



The coil, antenna, ground, and phones

The coils for these sets are typically wound around a 1 1/2 to 2 1/2 inch (38 - 64 mm) diameter core, using 75 to 150 turns of 24 to 20 gauge wire. These are typical numbers, not critical. What is critical is that

the individual loops of wire around the coil are wrapped touching the next one over, but that they do not ever overlap. It is also important that whatever attaches the coil to the base can not touch the coil's wire, especially if it is a metal tack or nail. A coat of shellac or varnish helps to keep the coil together. Let it dry thoroughly before using. If a wiper type switch is used, the varnish will need to be scraped away along its path.

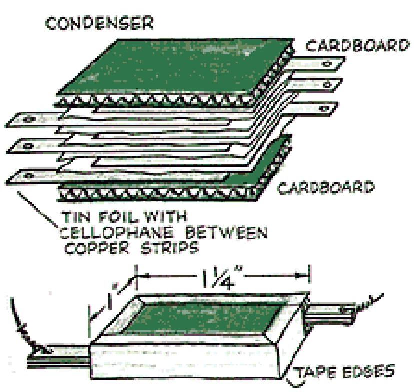


Ideally, the antenna should be 100 feet (30 m) or so long, and strung as high as possible. Insulated or non-insulated wire can be used. Either way, the un-insulated ends should not touch anything that will ground them. It is best if they are tied off to ceramic or plastic insulators, which can in turn be tied off between two high points outdoors, such as a tree limb and your house. Never string an antenna anywhere where it has even the slightest chance of coming into contact with a power line, or in a place where you will need to go near a power line to hook it up. Always take the antenna down if a storm or lightning is predicted. It is safe practice to add a lightning arrestor to you lead wire. You can purchase in many radio and electronic hobby shops antenna kits which include the antenna, insulators, lead wire, and lightning arrestor.

The ground wire can be attached to a metal cold water pipe, or to a metal rod stuck a couple of feet into the earth. Do not attach it to a line carrying gas or electricity.

The headphones (or earphone) need to be high the impedance type designed for crystal sets. They are still available through electronics suppliers and some hobby shops.

The capacitor

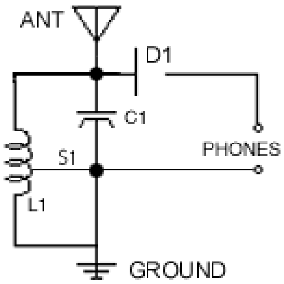


The capacitor, or condenser, though not essential for operation of these sets, does help to refine their use when it is added. More complicated sets have a variable capacitor. For the simplest sets, however, a fixed capacitor of around .002 mF or so is sufficient. A capacitor is also very simple to build. The Cub Scouts, being the great caretakers of crystal radio lore that they are, included this picture in the 1954 edition of the Wolf Cub Book. It lacked annotation of any kind other than what is here. The most important thing to know is that all of the tinfoil pieces need to be completely insulated from one another. They cannot touch each other in the least. The whole thing should be bundled tightly with cellophane tape. Also, aluminum foil is more common these days than is tin foil. It will work just as well.

Set one

What is presented here in crude ascii schematic is the simple basis of many simple crystal sets. This is not intended to tell you how to construct a particular set, but it should be enough to get a design started.

The diode D1, a germanium diode (1N34A or eq. usually recommended), is the detector, and in old sets this would have been the crystal and cat whisker assembly (see "A note about the crystal detector", above). The capacitor can either be a standard mica type of around 0.002 mfd, or a simple variable type, which you can easily build yourself based on a simple design of two metal or metal clad plates, which can be slid apart or together, and which are separated by an insulating material

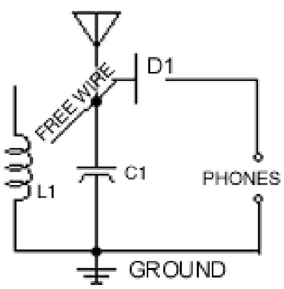


(kraft paper). L1 is the coil. Volumes could be and have been written on coils. A very simple one can be made with a 5 or 6 inch (127 - 152 mm) long, 1 inch (25 mm) diameter plastic pipe, wood dowel, or any fairly sturdy non metallic cylinder that can be easily worked with. Wind using magnet wire (#16 will work). Secure the free ends to the former somehow. The enamel should be sanded off the ends before including them in the circuit. You will have to mount the coil so that it does not contact the base. Sand the side lightly that switch S1 contacts. S1 is a simple piece of metal shaped and fastened so that it may slide across the coil. It is usual practice to attach it to the circuit with a screw or rivet loosely enough so that it can be pivoted to contact most of the coil. The ground can go to a water pipe (not a gas or electric pipe). A steel rod hammered 2 feet into the ground will also work. You can be as elaborate as you wish with the antenna. Don't use during an electrical storm! If you can't get it to work, flip the diode around. This might get things going. If not, check all your connections and make certain there is a good ground connection. You may also be using the wrong type of headphone. You will need a very high impedence phone. There are phones made specifically for crystal sets.

Set two

This design is a bit different, but mostly in the way the tuner is set up.

The coil for this set should be wound with app. 22-gauge wire, but it isn't critical. The form it is wound around is 1 to 2 inches (25-50 mm)



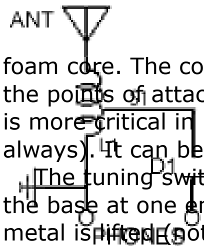
in diameter and 4 inches (10 cm) long. It is wound in pretty much the same manner as the coils in the other projects listed here. A few inches are left loose at one end, the wire is taped down, and winding begins. Every so often, a loop of wire is left out of the winding and twisted together. This loop should be 2 inches (50 mm) or so when stretched out. Try to keep their lengths uniform. They should be closer together near the end of the coil that will connect to the ground connection. The more of these "tails" that are made, the greater the selectivity of the set. Also, as with any of these sets, the more turns in the coil, the greater the range of frequencies that can be received. When the coil is mounted to the base, one end wire is joined to the circuit. The tails are thumb tacked to the base, sticking straight out in front of the coil. The coil's other end wire is tacked to the board along with the tails.

The capacitor is 300 picofarad. The enamel will need to be stripped from the coil's free ends as well as from the tails. The wire that is shown as a "free wire" in the schematic is actually the tuner. It attaches to the coil along it's tails to select frequency.

Set three: bare bones set

A crystal set can be very simple to very complex. If you want to go the complex route, which will produce a much more sensitive and tunable device, I suggest checking out the Xtal Set Society, which produces several fine books on the subject. If you want to construct a very simple one, then the schematic below is about as simple as you can get. It won't produce the easiest set to tune, but it is a great first set, and you will, if you are patient, be able to pick up several stations using it.

Using a toilet paper roll, poke two small holes about a half-inch from each end. Pass about one foot of the free end of a roll of magnet wire (#16 or so) through one of the holes, from the outside of the tube to the inside. Tape it in place. Wind the coil, making sure the adjacent windings touch but do not overlap. It should be wound firmly. When you get near the second hole, roll off another foot or so of the wire and cut it off from the roll. Pass the end through the second hole, and tape in



place. Mount the coil on the base, which is a 5 by 7-inch or so piece of wood, corrugated cardboard, or foam core. The coil should be mounted with spacers at each end, under the points of attachment, so that there is open air all around the coil (this is more critical in more sensitive sets, but it is good construction practice always). It can be attached with push pins or small brads.

The tuning switch (S1) is a piece of copper strip, which is mounted to the base at one end with a screw or rivet so that it may turn freely. The metal is lifted (not sharply bent) so that it sits on top of the coil, making good but gentle contact across the entire range. It should be positioned so that the mounted end is 2 or three inches from the coil, and centered with the coil (long ways). It is 1/4 to 1/2 inch or so wide, and long enough to cover the entire range of the coil. There should be no sharp edges, as this will wear out the coil.

You will need to add 3 terminals, two on one end of the base, and one on the other (at opposite ends of the coil). Small nails or pins work well. Sand off the enamel from the free ends of the coil's wire. Attach the wires to one of the terminals on each side. Lightly sand off the enamel under the path where the switch swipes the coil. A diode (1N34A or eq.) is attached between the attachment point of the switch and whichever of the 3 terminals is not attached to the coil. The banded side of the diode faces away from the switch.

The antenna wire attaches from the side of the coil that is opposite the diode (the side with only one terminal). It should be as long as is practically possible. Attach the ground to the terminal on the opposite side that is attached to the coil (not to the diode). The ground wire is then attached to a cold water (not gas!) pipe. High ohm headphones (the type designed for crystal sets) or an appropriate earphone is attached to the two terminals between the diode and the coil. A .001 - .002 uF capacitor can be added across the earphone terminals (not necessarily essential).

The switch needs to make good contact with the coil. If necessary, bend the end somewhat in its middle, long ways, to refine contact. Or else, solder a short piece of heavy wire to the bottom of the contact point.

Set four: Cub Scout set

This is a set which appeared in the 1943 Wolf Cub Book, part 1, pp. 75-77. The text is verbatim. It may be public domain by now, but assume for now that the Boy Scouts of America hold the copyright. There is also a nice gif image of the set from the manual. If you have trouble getting this, let me know and I will see what I can do.

How to make a simple
CRYSTAL RECEIVER

A-Dry a cardboard mailing tube in the oven, then paint with a coat of shellac. The tube should be about 6 or 7 inches long and 2 1/2 inches in diameter. Buy one pound of 26-gage (B. & S.) single cotton covered wire. Start and finish winding one half inch from ends of tube. Then shellac all over again. When dry, fasten down to a baseboard at each end, with a screw and washer to prevent it from touching at any point.

B-Cut a strip of cardboard as a test place for selector. When length has been determined, cut a brass strip the same size. Screw this down at a slight angle and mark on coil just where it touches. Fold a piece of sandpaper and with the folded edge remove the shellac and covering from wire on coil. This will leave an arc the bras strip will touch. In fastening on brass selector, use two fibre washers.

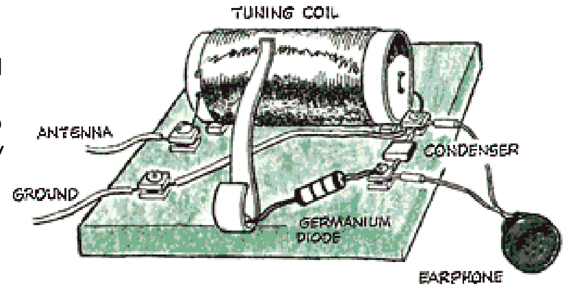
C-One end of wire from coil should go to "ground" clamp. Wire from selector should go to "antenna" clamp. Other end of coil wire should go to crystal detector. Run a wire from "ground" clamp back to one phone binding post. From other binding post, run wire to crystal. Between the phone posts, connect an .001 or .002 microfarad receiving-type fixed condenser, which costs very little.

This type of receiver works best when within 25 miles of a broadcast transmitter. Antenna and ground connections should always be tight.

- end of article

By the 1950's, the basic set changed only slightly, and has remained pretty much the same up to current Cub Scout manuals.

Final notes



This page is intended to get you started on a simple set, as well as to introduce a bit of theory to assist in constructing more complex sets. Crystal radios can be refined and precise pieces of equipment with careful design and construction. There is room for experimentation in every aspect: basic design, the coil, rheostats, the antenna, traps for the antenna (which help to filter the signal before it reaches the set), and so on. Changes in these areas can effect the sets sensitivity, range, accuracy, and even volume. Most of this is beyond the scope of this page. If you want to pursue crystal sets further, a good place to start is the Xtal Set Society. Also, you will find out a great deal on your own by experimentation.

Crystal radio lore

Gordon Johnstone writes:
"My grandfather was one of the first electric torpedo men on the Royal Navy ships during the first World War. He built one of the early crystal radios for my grandmother, but was annoyed at only one person being able to hear at any time. So he took a large pudding basin, and mounted the headset a little up from the base inside. Voila, early parabolic loudspeaker system."

Thanks, Gordon!

Construction of a diode

If you want to try your hand at making your own diode, Allan Charlton, of Sydney, Australia, adds:

"When I was a kid in a small town in Tasmania, Australia, our school was at the base of a hill, and the local radio transmitter was on top of the hill. We had lots of fun with crystal radios.

This is how we made our diodes:
Take a small length of glass or plastic tubing--an inch of the case of a plastic pen works well. Close one end with wax, sealing a wire through the wax. Pour a little copper oxide into the tube: enough to cover the end of the wire. Fill the rest of the tube with copper filings or turnings. Poke a wire into the copper filings or turnings (but don't let it go down to the oxide) and seal the end of the tube with wax.

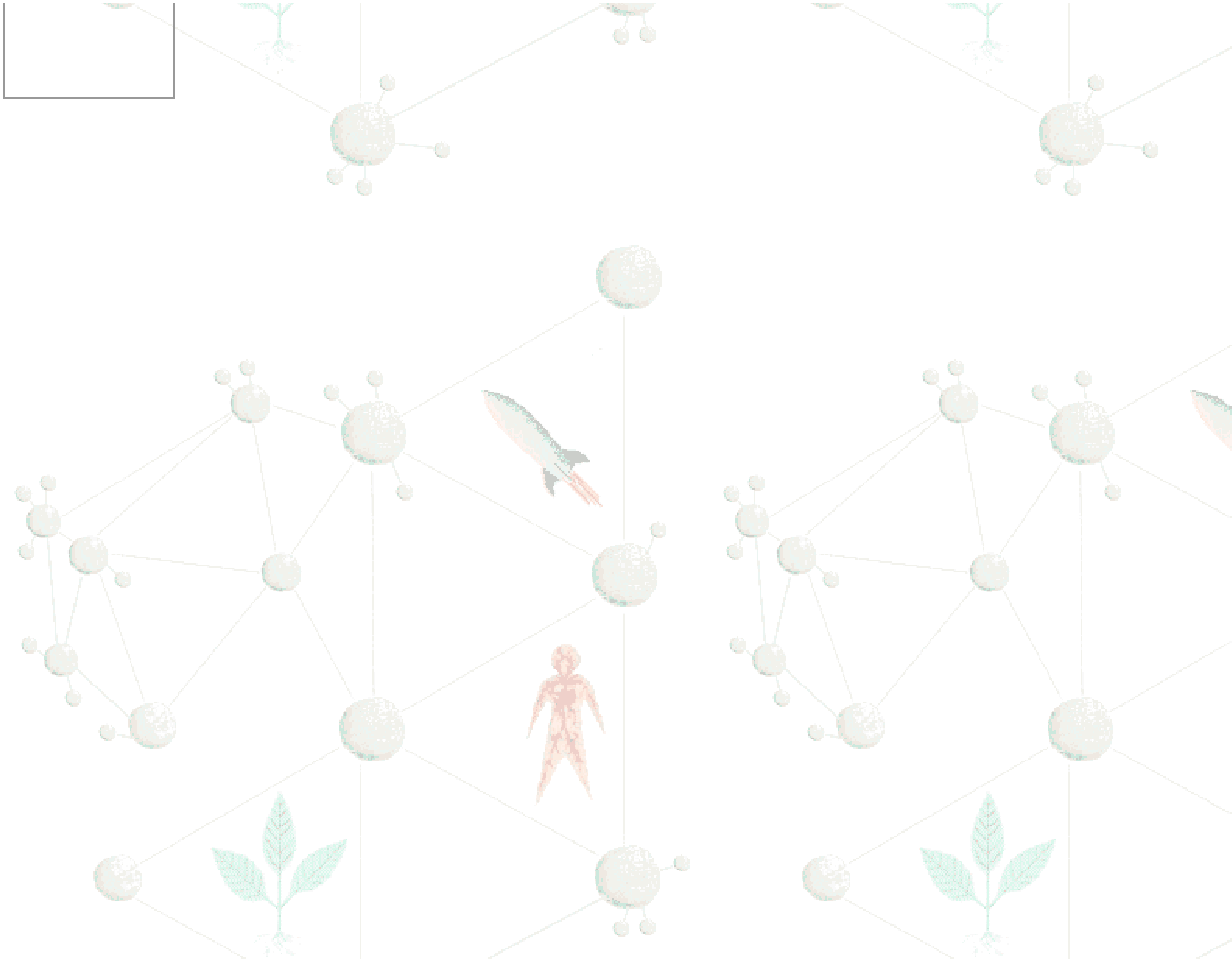
Can't find copper oxide?
Throw some copper wire into a fire. When it's cool, scrape the oxide off the wire. Yes, there are two oxides of copper, a red oxide and a black oxide, and they both work well. We preferred the red, but I have no idea why."

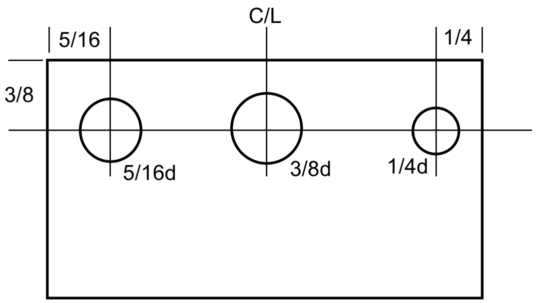
For the truly intrepid builder

In truly keeping with the spirit of this site, that is, making things from stuff you may find around the house, try your hand at the foxhole radio, which is so wonderful it get its own page.

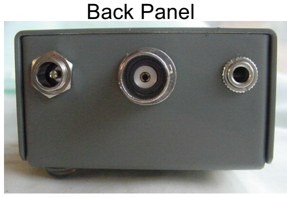
TOP | HOME | INDEX | CATEGORIES
http://bizarrelabs.com

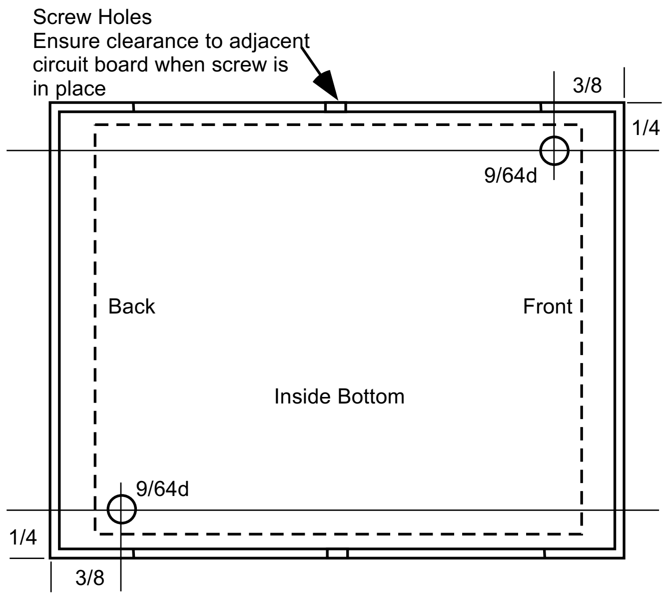
Last updated Dec 30, 2008

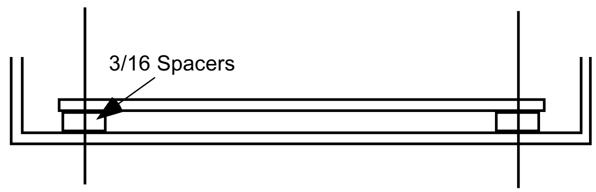


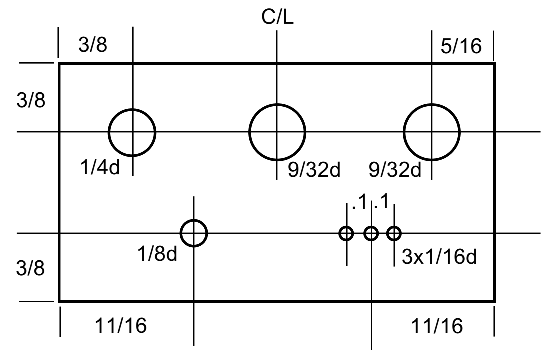


Back Panel

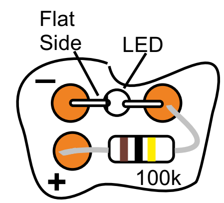






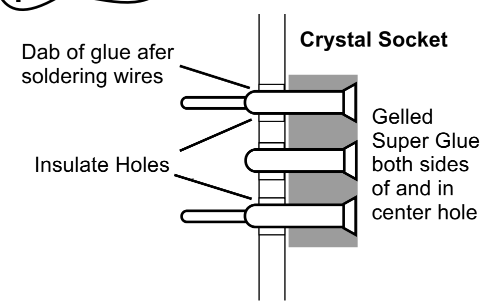


Front Panel



Back of panel view -- connect power leads to pads as shown.

Good intensity with 100k and only about 140uA load at 14V



Parts List:
(These parts fit with the dimensions shown.)

BC#1 Enclosure -- Hendricks QRP Kits

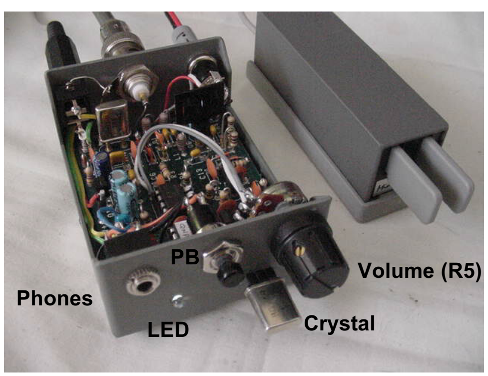
Power Jack -- 5.5 x 2.1 mm Mouser # 163-4304
BNC Jack -- Mouser # 161-9323
Stereo Jack (2) -- Mouser # 161-3402
Push Button (Grn) -- Mouser # 103-1216
Pot, 1 Meg -- Mouser # 313-1210F-1M
Knob -- Mouser # 450-CE15
LED Super Bright -- Mouser # 604-I.7104SEC/H
Bumpers (4) -- Mouser # 517-SJ-5306CL
Resistor, 100k 1/4 Watt
Crystal Socket -- 3-pin SIPP
Manhattan pads (3), 3/16 dia
Jelled Super Glue

Important:
Verify that there is proper clearance on both sides of the panels. Also, to the adjacent components on the circuit board. Adjustable controls often use much more space behind the panel than in front.

BC#1 Enclosure and Rock-Mite

W5USJ 28Nov'06

Crystal Socket/3-Pin SIPP
Carefully drill 3 holes 1/16 dia on 0.1 inch centers. (Actually 3 pilot holes with a #60 drill first then the 1/16 drill.) The center pin is used as part of the mechanical support but cut off up to the large diameter part of the pin. The cabinet is painted from both sides to ensure plenty of paint in the holes for insulation. The SIPP socket is mounted by putting a small dab of gelled super glue in the center hole then inserting the socket. Put another small dab of glue on the back side of the center pin. Hold the socket in place for a couple of minutes then set it aside to dry overnight. After connecting a couple of short flexible wires to the socket pins, put a small dab of glue on the back of each of the remaining two pins.



du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Saturday, July 6, 2013

Switch Mode Power Supply Unstable Output Cure

I got this switch mode power supply from a friend and my plan was to use this on my 80W linear amp. Things went the other way when I tested this supply with my 80W amp. The output voltage won't stay at 12V and every time i keyed my transceiver, the output voltage swings to 15V and sometimes the worst hitting a peak at 17V which by any moment will surely blow the PA transistor of my amp. It took me a quite a while to figure out what was causing the issue but then it was the stray RF reaching the PWM switching regulator IC was the main culprit. My verification includes bringing a 6W portable hand held transceiver close to the switch mode power supply and pressing the PTT while monitoring the output voltage of the power supply. Every time i pressed the PTT the output voltage jumps to 17V and the proximity of the rubber ducky antenna is directly proportional to the increased in output voltage of the power supply.

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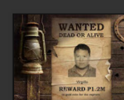

hevirred

Ham since 2000.

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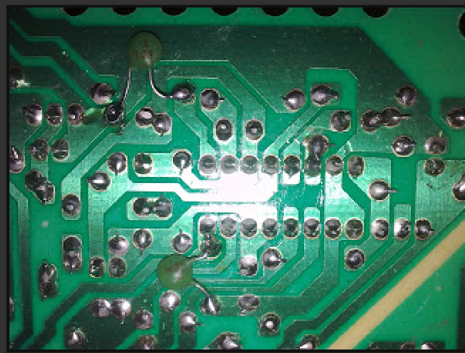

I got the courage to disassemble the switch mode power supply to access the circuit board and found the only chip mounted on the board. It was a AZ7500E pulse width modulator regulator chip that runs this power supply and found some important pins that are responsible for its regulation. I tried to bypass to ground pin1 and pin16 (both were (+) inputs of its built-in error amplifier) using a 0.01uF ceramic capacitor. After the modification I quickly reassembled the power supply and test again for stability and surprisingly works now normally. --- 73 de du1vss

Posted by hevirred at 10:36 PM

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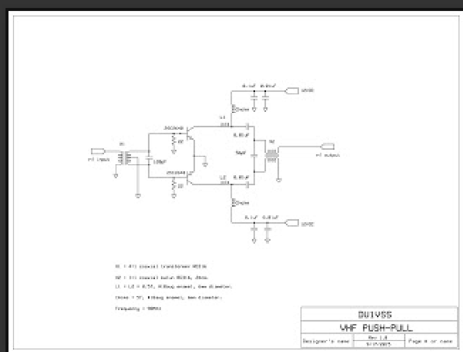
du1vss home brews

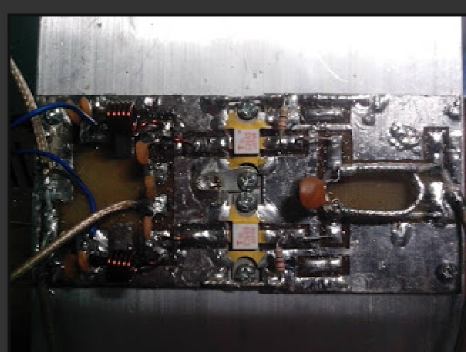
All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

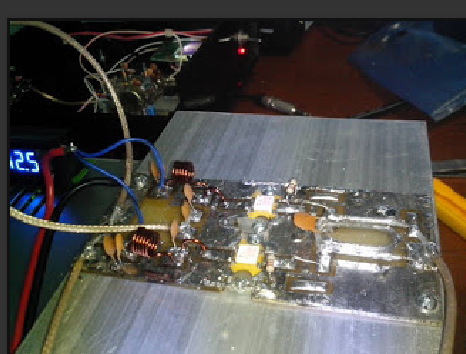
Thursday, September 17, 2015

FM Broadcast 55W Push-Pull RF Amplifier

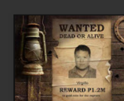


This prototype rf amplifier uses two 2SC2640 VHF power transistor wired in push-pull configuration. The 50 ohm impedance of the input is transformed to lower impedance by the 4:1 broadband coaxial cable transformer providing a close match to the base of the two transistor. To operate in class C, the base of the transistor must be at ground potential so the secondary winding of the 4:1 coaxial transformer is grounded at the center position(null). The impedance of both collectors are transformed by the combination of inductors L1 , L2 and the 120pF capacitor and further transformed by the 1:1 coaxial balun.





About Me



hevirred

Ham since 2000.

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Both the 4:1 coaxial transformer and the 1:1 balun are made from RG316 teflon coaxial cable and these are cut to a certain length in order to operate at the highest cut-off point which in this case at 110MHz. Actual test of the prototype amplifier, I was able to measure 55 watts output from a 1.5 watts input. ---73 de du1vss

Posted by hevirred at 7:06 PM

9 comments:

Gabriel Ueta April 2, 2016 at 4:01 PM

Hello,

I think there was a misunderstanding. Coaxial cable RG316 has impedance of 50 ohms. Wouldn't the cable used have to have 25 ohms?

Reply

Replies

hevirred April 2, 2016 at 11:22 PM

You are right, rg316 is a 50ohm cable. This cable was intentionally used as a 1:1 coaxial transformer hence no transformation is required. This 50 ohm cable recombines the out of phase output of each transistor into unbalance output.

Gabriel Ueta April 3, 2016 at 10:48 AM

This comment has been removed by the author.

Gabriel Ueta April 3, 2016 at 11:32 AM

Right, but the cable used in the transformer 4: 1?

hevirred April 5, 2016 at 2:14 AM

I read in some books that 4:1 transformer is made of 25 ohm coaxial cable but I have also tried several HF amplifier projects that uses binocular ferrite transformer and just wires for its broadband matching transformer and it works just fine. It provides good input and output match in my amplifier so I dont bother looking for a 25 ohm cable. You will also find that most commercial hf transceivers like icom, yaesu and kenwood also uses broadband transformers that are made just with binocular ferrite transformer and some insulated wires. I believe also that the turn ratio between secondary and primary winding determines the impedance ratio of the transformer. Thank you by the way for dropping at my blog, only a few these days are interested in ham radio. 73 de du1vss

Reply

Gabriel Ueta April 6, 2016 at 1:51 PM

You are welcome. Do the transistors have equivalent? It is difficult to find them.

Reply

hevirred April 7, 2016 at 5:48 AM

You can try the mitsubishi 2sc1946a but this is hard to find now.

Reply

Gabriel Ueta April 11, 2016 at 12:15 PM

This comment has been removed by the author.

Reply

Pedro July 21, 2016 at 10:13 AM

Hello,

I was also in doubt. If I use 25 ohm cable, is the impedance of the transformer will be reduced by half? Another thing: what are the dimensions of input transformer? It was not clear for me to build it.

Reply

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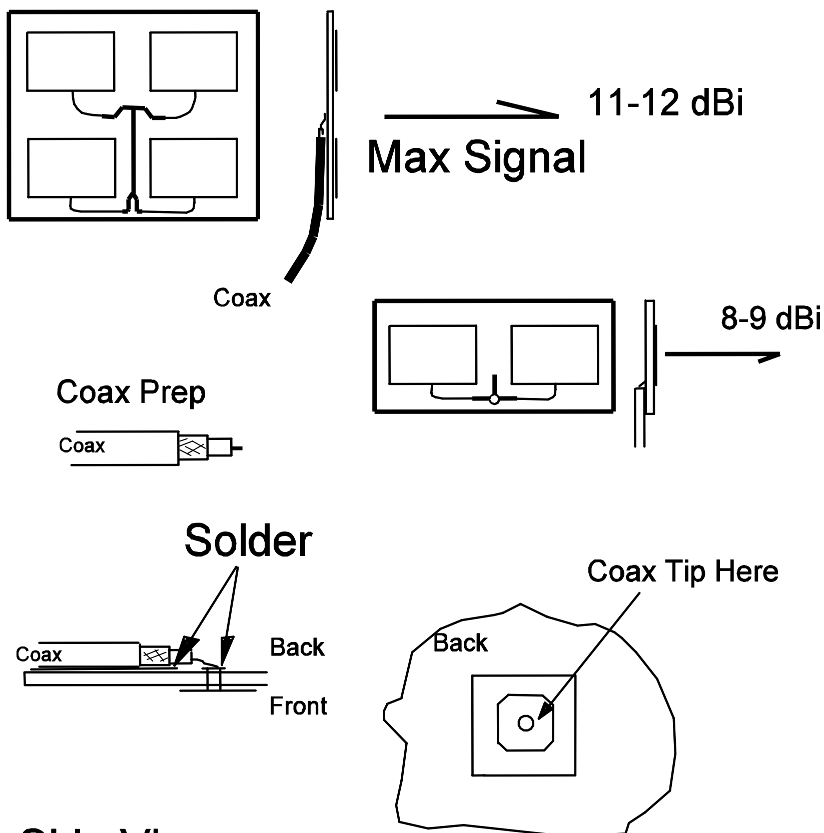
5.8 GHz Patch Arrays

WA5VJB

Vertical Polarization
As Shown



Side View

Uses: ATV Beacons Wi Fi

Repeaters Wireless Systems

Dish Feed Links MIMO

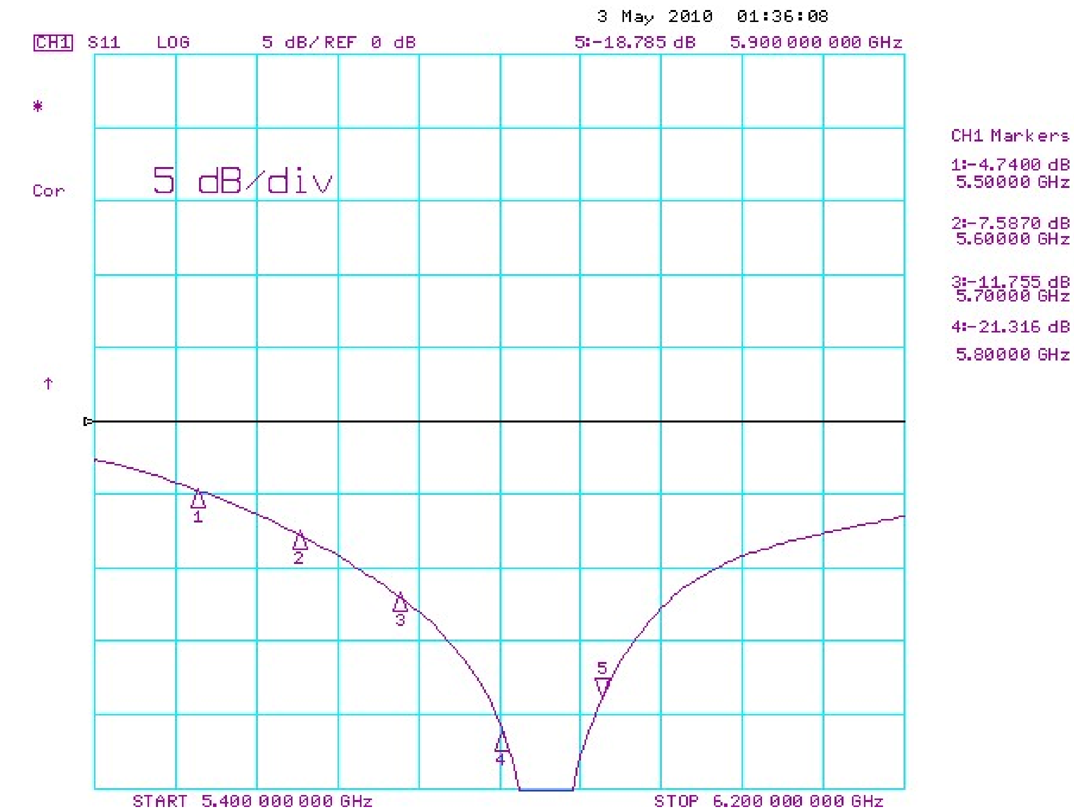
Notes:

The Coax solders to the back of the antenna.

RG142 and other Teflon Coax's work well.

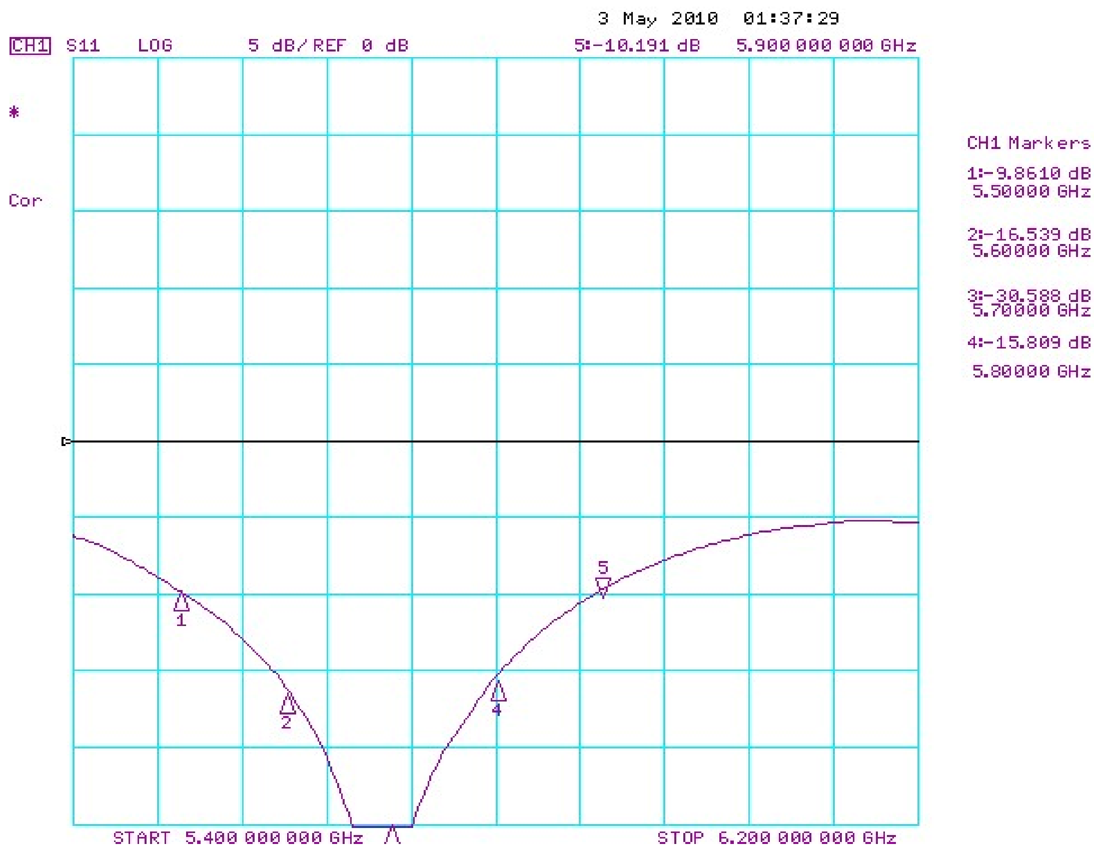
Use 50 Ohm Coax

Title 5.8 GHz Patch Arrays		
Size B	Number NTMS	Rev A
Date:5-3-10	Drawn by: KEB	
File Name: 58pdata.pcb	Sheet 1 of 1	



Quad Patch Return Loss

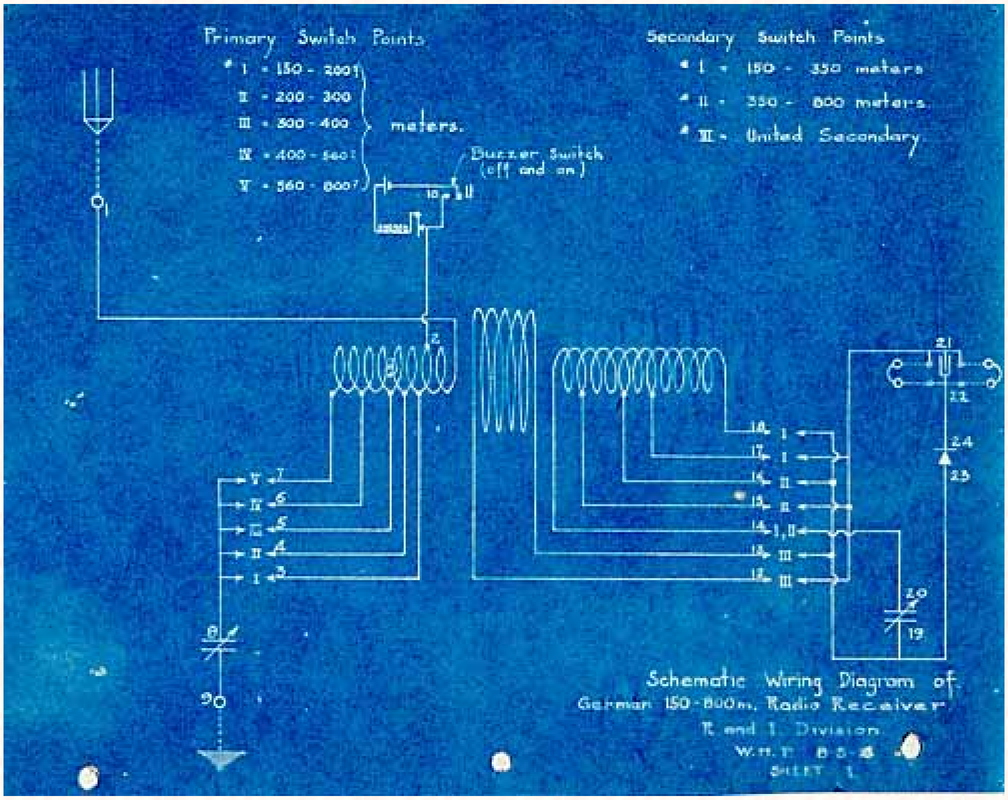
==

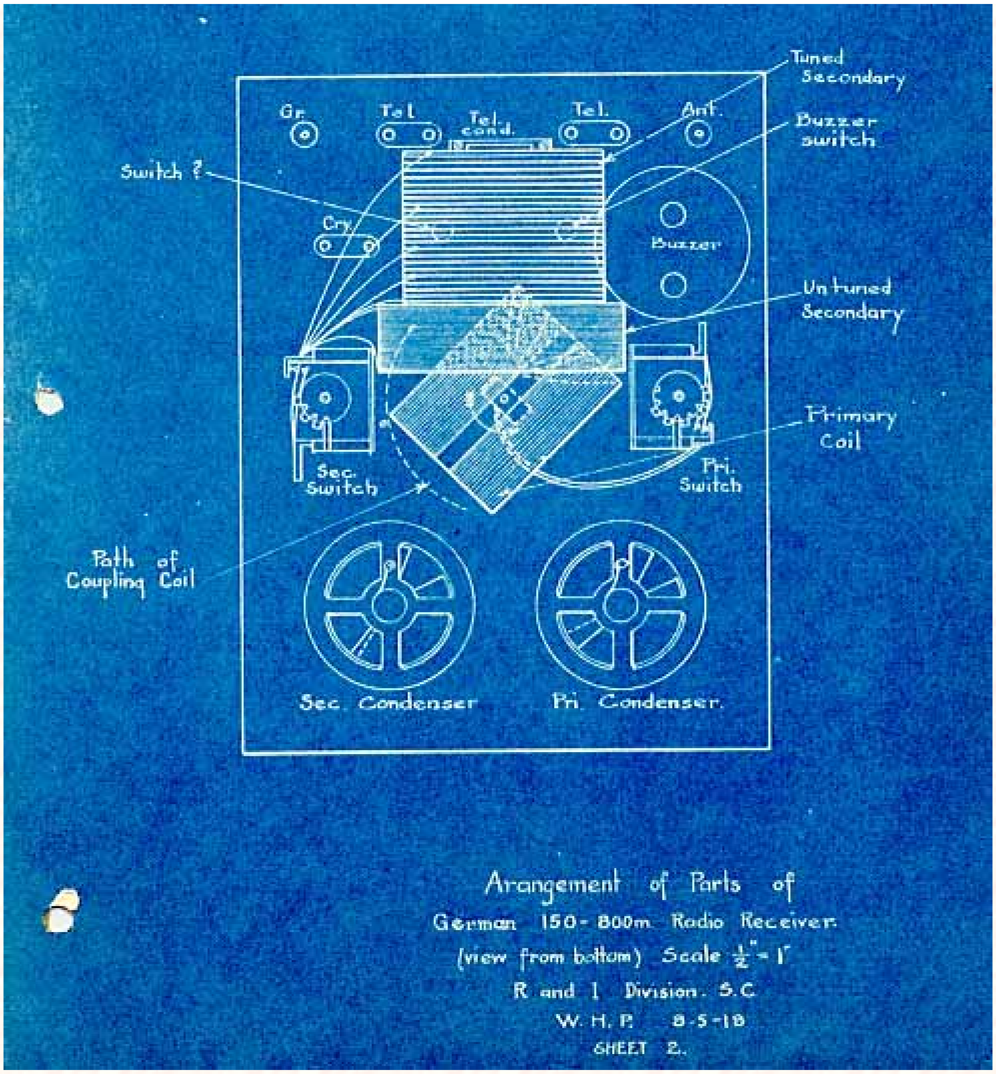


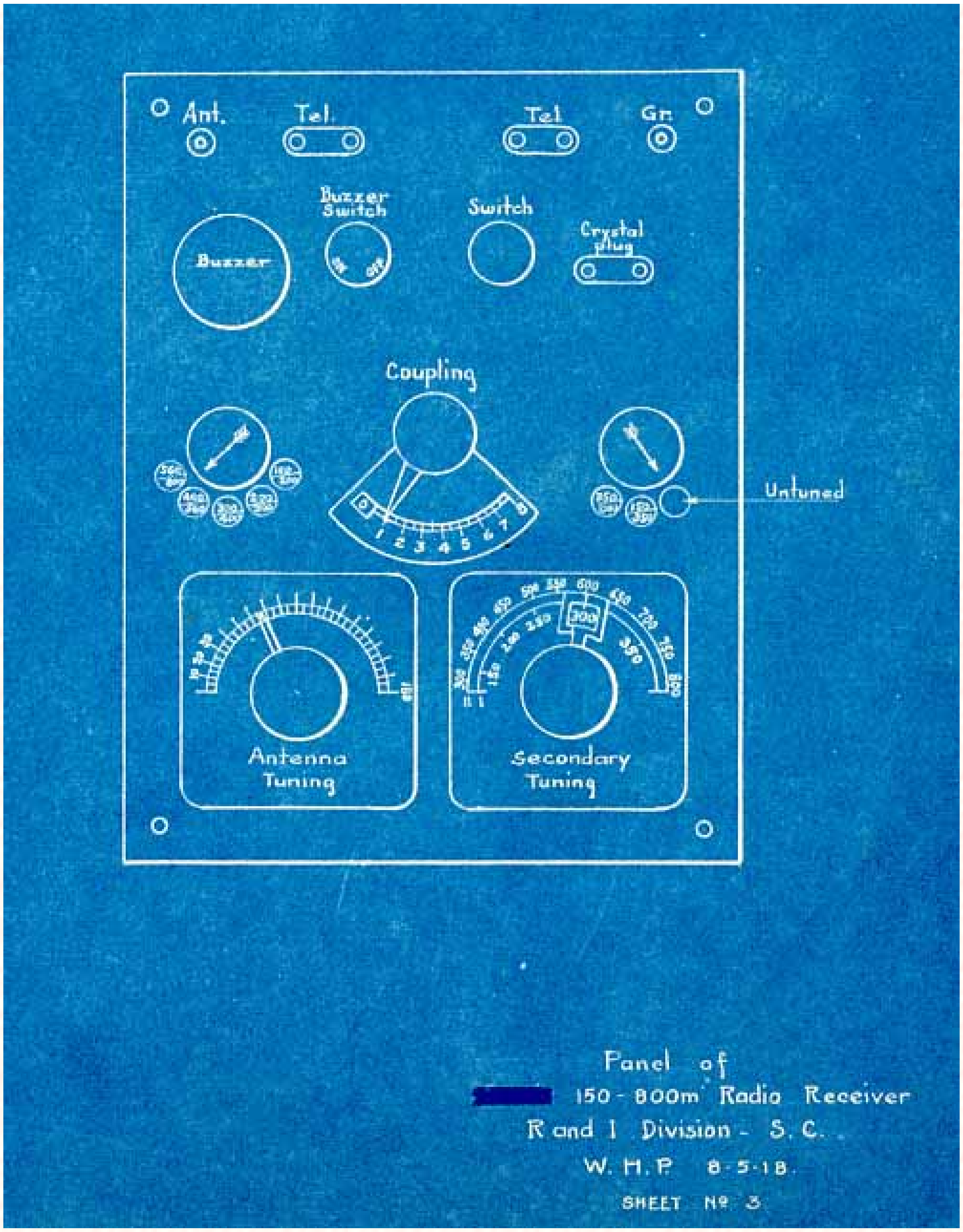
Dual Patch Return Loss

Another of the primary tasks performed by the R&I Division was the study of captured equipment.

Drawings of a German receiver.




Tuned Secondary
Gr.
Tel.
Tel. cond.
Tel.
Ant.
Buzzer switch
Switch ?
Cry.
Buzzer
Untuned Secondary
Primary Coil
Sec. Switch
Pri. Switch
Path of Coupling Coil
Sec. Condenser
Pri. Condenser.
Arangement of Parts of
German 150-800m Radio Receiver.
(view from bottom) Scale ½" = 1"
R and I Division. S.C.
W. H. P. 8-5-18
SHEET 2.


Ant.
Tel.
Tel
Gr.
Buzzer Switch
Switch
Crystal plug
Buzzer
Coupling
Untuned
Antenna Tuning
Secondary Tuning
Panel of
[redacted] 150-800m Radio Receiver
R and I Division - S. C.
W. H. P. 8-5-18.
SHEET No 3

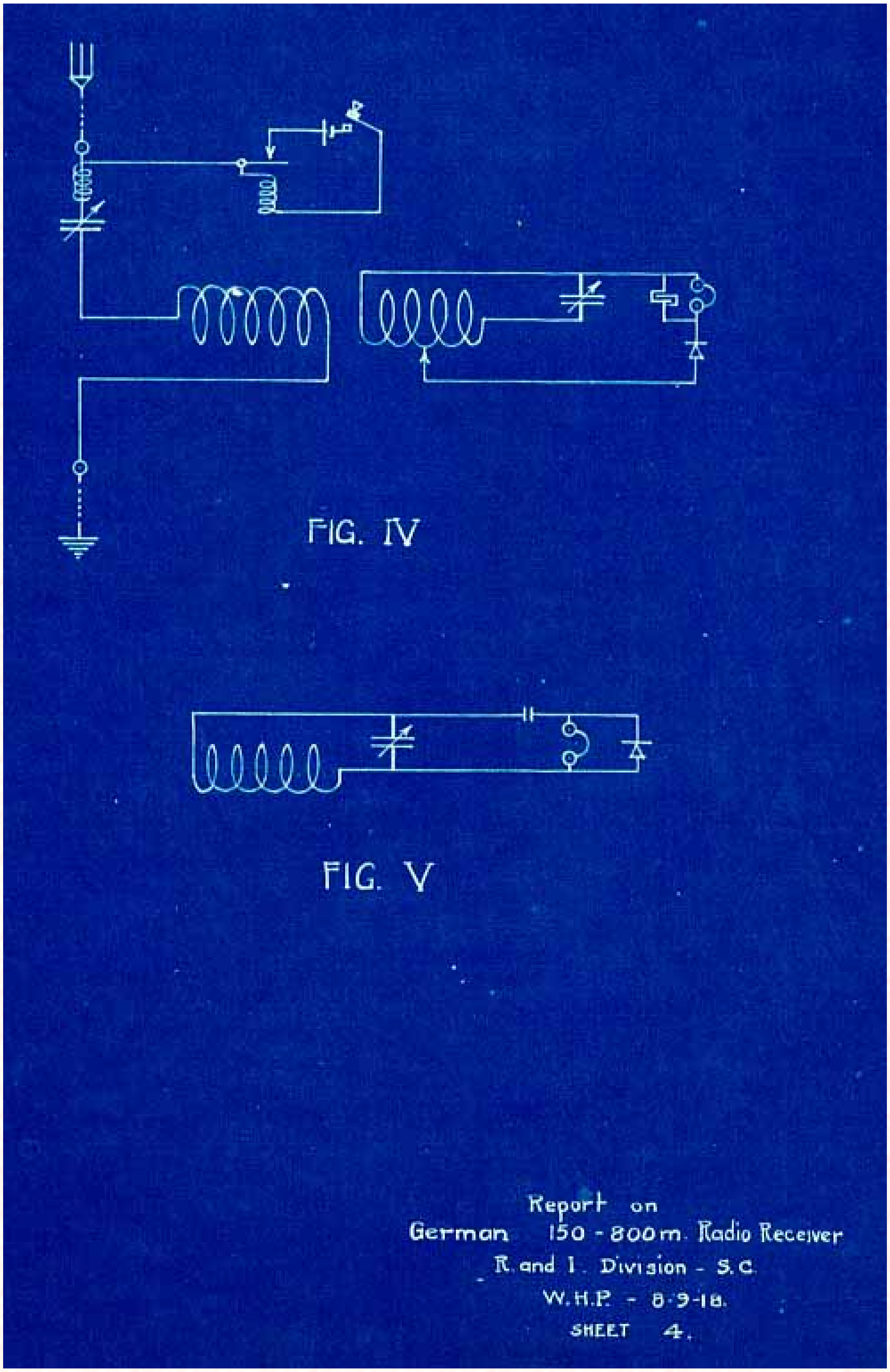


FIG. IV
FIG. V
Report on
German 150 - 800m. Radio Receiver
R. and I. Division - S.C.
W.H.P. - 8-9-18.
SHEET 4.

(More)

Installing the N4YG DDS in a Ten Tec Omni D

By Pete Juliano
radioguy90@hotmail.com

Every once in a while luck finds a path to our door and it was with such a lucky happening that I purchased a Ten Tec Omni for $90. The radio had a few technical problems which were resolved in about 15 minutes at no cost and a simple cleaning of one contact. Lucky me! In no time I was on the air and despite adequate warm up periods the PTO drifted some 100 to 200 Hz. In today's world that is unacceptable.

My first thought was to install an X-Lock-3 frequency stabilizer from Cumbria Designs in the UK. I have made three installations of the X-Lock in a HW-101, Corsair I, and a TR-7 so I know it works. But then there is the ever PTO rebuild scenario with the Ten Tec PTO's. So that solution was discarded in favor of installing the N4YG DDS board. Using that board not only provided a highly stable VFO source but it came with bonuses such as being prebuilt and tested, having an A, B and Split VFO functionality as well as variable rate tuning for very fast or slow QSY. Another bit of icing on the cake is that the board can be made to remember the last frequency when you power down. How great it is to be able to power up the radio and it already is on frequency. Finally an RIT function is embedded in the DDS board that gives about a +/- 1.5 kHz spread.

Thus started my journey of acquiring and installing an N4YG DDS. The website for the N4YG DDS is quite good and has much information

including several who proceeded me along this path namely AA4BQ and W0CCA. After several rounds of emails and profiting from the prior experience database, I considered the two options for installation. One is to physically install the DDS inside the Omni D and the other is an external install.

The internal installation most likely would require some shielding to prevent unwanted signal from entering the radio. Such was the case with one of the prior installations. Internal installation requires physically removing the PTO assembly, disconnecting wiring to the Spot switch and rewiring of the Offset pot. Installation of the DDS board itself requires drilling some holes in the Omni D sub-chassis. For those not so experienced in working on parts and assemblies in tight quarters this could prove to be a daunting task. The internal install also means that if for some reason the radio would be returned to stock, reversing the process while not impossible would once again take some experience and skill.

The other option is the external installation where the DDS would operate much like a remote VFO. That is the option I chose. This option is minimally invasive and requires pulling the VFO jumper on the back panel of the Omni D and inserting the output of the DDS into the RCA jack marked "VFO In", a connection to +12VDC at the Auxiliary +12 VDC jack also located on the back panel and an internal connection to any board or control where there is an "R" voltage present. Three connections and that is it. A return to stock involves reinstalling the VFO jumper, disconnecting the +12 VDC and removing the connection to the "R" pin. One minute max is about all that would take. The internal PTO, and Offset selection are inactive using this method and everything is now done on the Remote DDS. Below is my DDS installation sitting next to the Omni D. The yellow wire is the temporary connection to an "R" location.

First some baseline information about the stock Omni D which is essentially a single conversion radio with a 9.0 MHz IF. On all stock bands except 20M, the 5.0 MHz PTO signal is heterodyned with various crystal frequencies to provide the proper injection frequencies. You will note that the Omni D as well as other Ten Tec Radios define their SSB operation as normal and opposite versus USB or LSB.

The reason for this is that below 20M the PTO + Crystal Frequencies are on the high side of the incoming signal which causes a sideband inversion (ie LSB) using the same Carrier Crystal for 20M and above the PTO + Crystal Frequencies are on the low side (on 20M there is no heterodyne crystal) so USB results. Clever approach. But in all cases the PTO tunes the same frequency range 5.0 to 5.5 Mhz. The DDS is merely substituting for the PTO with the added functionality as previously mentioned.

So what comes in the N4YG DDS kit? The complete kit includes the DDS board, the interface cables, high quality optical encoder, and 4 each mounting pillars. In my case N4YG threw in a few LEDS and some

dropping resistors. Since the premise of the kit is an internal installation the Omni D, the Spot Switch and Offset control would be pressed into service as a mode switch and RIT control. These are not used in the remote installation. Thus I had to supply a momentary Push Button Switch and a 25K pot for the RIT. I didn't have a 25K pot so I used a 100K Ohm pot bridged with a 33K Ohm ¼ watt resistor. The equivalent parallel resistance is 25 K Ohms.

The table below defines what is required to build the remote installation.

Item	Supplier	Comments
DDS Board	N4YG	
Optical Encoder	N4YG	
Cables/ Mounting Hardware	N4YG	
Spot Switch	Owner	Use a momentary from Radio Shack
25K RIT Pot	Owner	I used a 100K + 33k Bridging Resistor
Green LED	Owner	Standard Green LED from Radio Shack
Red LED's (2)	Owner	Standard Red LED from Radio Shack
LED Holder	Owner	Holder available from Radio Shack
Knob Large	Owner	I used a TT knob from an Omni VI
Knob Small	Owner	I used a TT knob from an Argosy
150 Ohm (3)	Owner	¼ watt from Radio Shack
Case	Owner	Surplus Power Supply Case from a TT 262G
Misc. Wire and Connectors	Owner	Junk Box.

The wiring instructions for the Corsair II were used for the install and that is where N4YG has done a super job at labeling the DDS Board connectors. Each wire is marked so it is clear what goes to where. In the case of the VFO A, B and Split LED's I used a 150 Ohm dropping resistor is series with the wire which are connected to the anode side of the LED (longer lead) and the cathode (shorter lead) of each LED is grounded. Larger values of resistance will make the LED less bright. I wanted the LED's to be in my

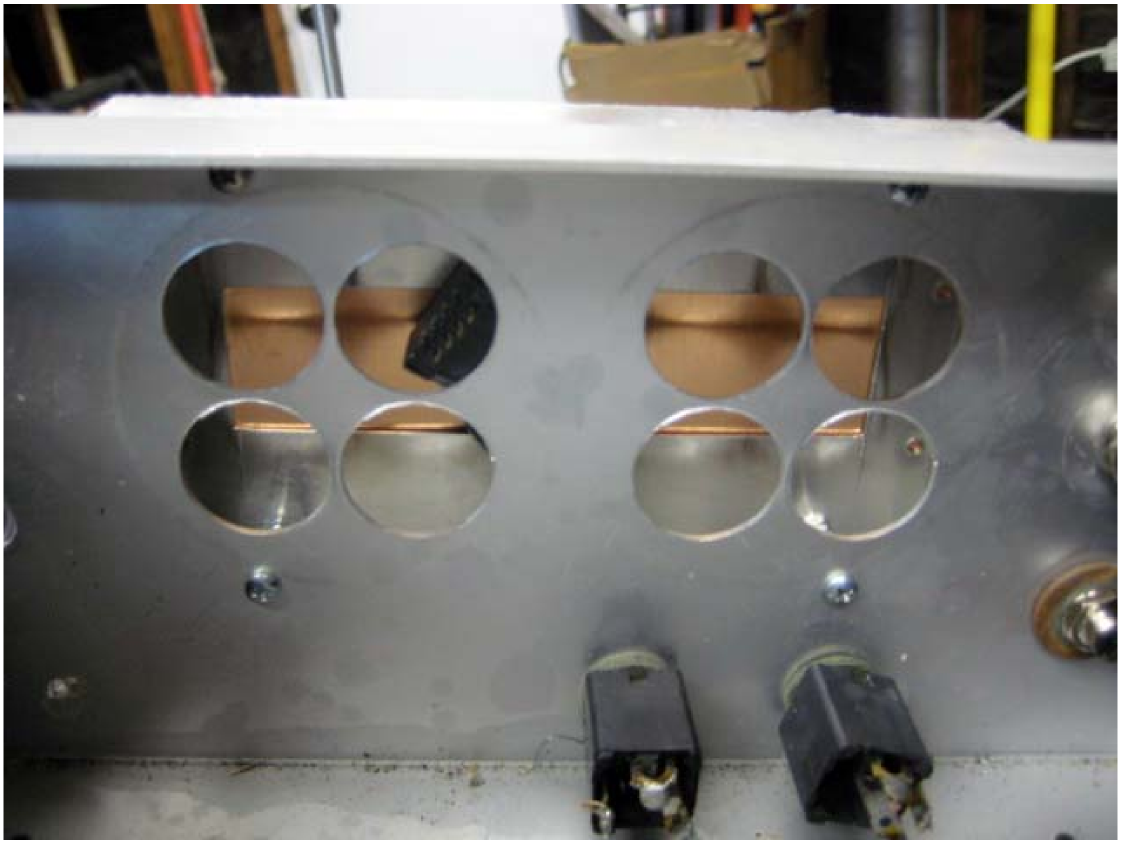
face and clear from a few feet away to clearly indicate which VFO was being used.

The N4YG DDS board is relatively small measuring some 3 inches by 3 inches and so there are many commercial enclosures that would work. That said having too small of a box will mean the remote DDS is moving all about the operating desk and anchoring the box to the operating desk does somewhat limit your flexibility.

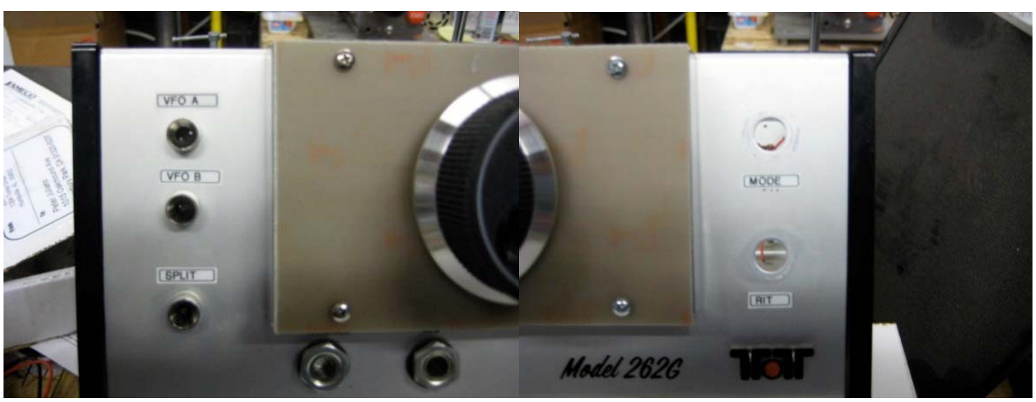
Enter the Model 262G TT enclosure. Several years ago I bought a Ten Tec Model 540 as a tech special which I modified to now have a digital display. When the Model 540 arrived there were two boxes and one included the Model 262 case which had been gutted and reused to have some sort of keyer built in. Thus I had a freebie case in the deal.

In looking at the case I could see where the front panel could be readily adapted for the DDS install. The Model 262G has two front facing speakers which are covered by a plastic frame and speaker grill cloth. Removing that reveals large holes in the front panel which would present some problems in the mounting of the optical encoder. My resolution of the problem was a sub-panel to mount the optical rotary encoder which is now affixed to the front panel. All of the other existing control and indicator holes were used without having to drill any additional holes. The 262G case may be a bit of an overkill in terms of space but it looks Ten Tec and is Ten Tec and so a perfect complement to the Omni D.

Following are some close up photos of the installation inside the 262G case

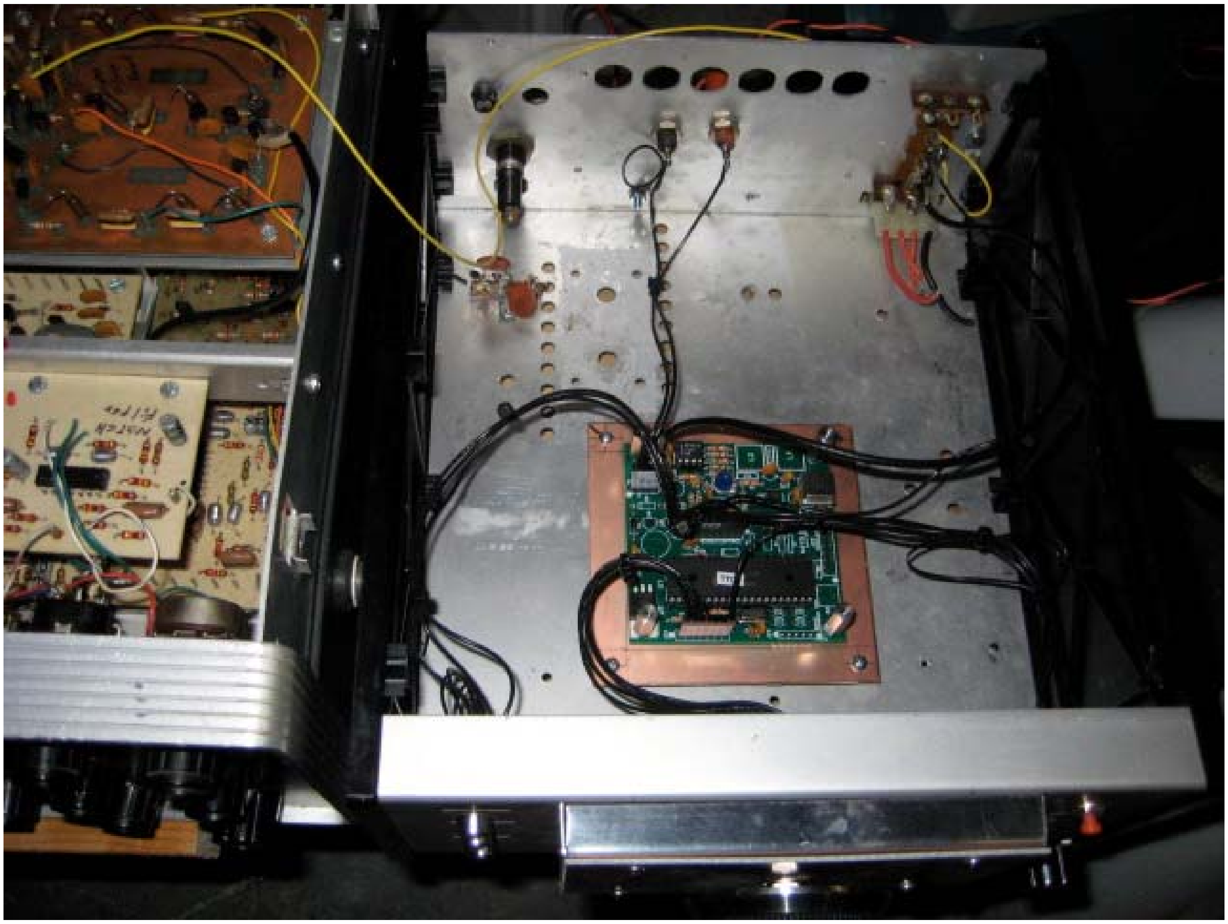


Backside of the front panel showing the encoder and the connection point



I have a small label machine from Brothers and made these labels which cover the original Ten Tec lettering.

Finally this is a photo of the internal portion of the 262G and how the DDS board was mounted internally. I purposefully mounted it in an open area and if required could add additional shielding around the board. That has not bee required.



A sub chassis of approximately 4 inches by 4 inches was cut from a piece of single sided copper PC board. The N4YG DDS board comes with four ¼ inch spacers which are used to mount the DDS Board on the Copper Board and provides a solid ground plane. The Copper Board is then elevated above the base of the 262G by four more spacers and thus provides a solid grounding to the Ten Tec case. Many of the back panel connections are reused to connect the input and outputs of the DDS board. There are two RCA jacks on the back panel both of which are floating and one of these is used to connect the RF Output of the DDS to the VFO Input port on the Omni D. I insured that the ground pin of the RCA Jack I used for the RF output was physically connected to ground.

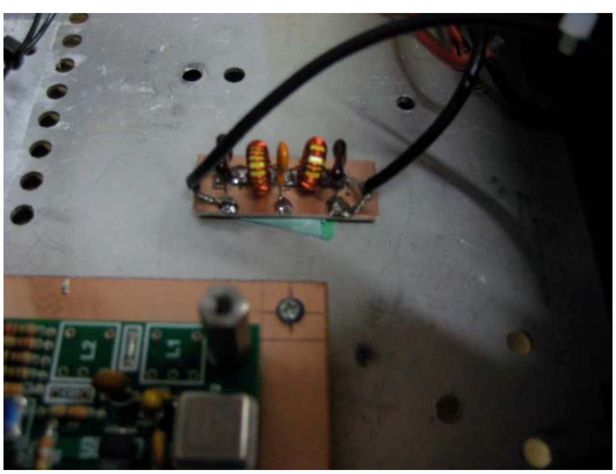
The DDS worked first time and I am happy with the result given the limitations of a 35 year old radio. The frequency stability is outstanding and

having the two VFO's and split operation puts in on par with the technology of today. Too bad more hams do not realize that with a bit of upgrading some of the old boat anchors can compete with the modern several thousand dollar radios of today. The total investment was less than $300 and it only took about 5 hours total to build the hardware and make the installation. Thanks Joe!

Refinement to the Installation

The Omni D, again a single conversion transceiver, uses crystal mixing to place the LO above or below the incoming frequency with the exception of 20 Meters where the LO is directly mixed with the incoming to achieve the 9.0 MHz IF signal. After a few days of operation I noted some "squeals and squeaks" only on 20 Meters which I quickly recognized as some possible harmonics of the DDS causing the issue. I have seen this before in several homebrew radios I have constructed and the cure was to insert a 5 MHz Low Pass Filter in line between the DDS and the Omni. The photo below, shows that installation and the parts values are 680 PF for the two outer capacitors, and 1000 PF (0.001 Ufd) for the center capacitor. The two inductors consist of 25 Turns of #24 on a T-37-6 powered iron core (yellow) form. This circuit is a lift from a project by W7ZOI published in QST in Dec 89 and Jan 90.

The Low Pass Filter did its job and so no more squeals and squeaks. I highly recommend that this be a standard installation feature for any Ten Tec applications.




De N6QW February 2014

PS: There is a youtube video showing the DDS in action with the Omni D

http://www.youtube.com/watch?v=WgdqXj5qeys&feature=c4-overview&list=UU4_ft4-oTdCMlWlL4XXHScg

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3 Band Portable Field Radio

Designed by Steve Weber. KD1JV

The updated PFR-3B now contains a rotary encoder and other minor changes to improve the performance.

Specifications

Bands : 40 meters, 30 meters and 20 meters
Tuning range: Full band coverage
DDS VFO with 50 Hz slow tuning rate and 200 Hz fast tuning rate
Mode: CW only

Receiver MSD: 0.2 uV typical
Selectivity : 300 Hz
Four crystal IF filter and 600 Hz center frequency audio band pass filter
Receive current, no signal typical:
Active, 47 ma
Idle, 34 ma

Transmitter:
5 watts at 12 volts, all bands +/- 10%
Transmitter current: 650 ma (40M) to 740 ma (20M) typical at 5 watts

Spurs: - 50 dBc maximum, all bands

5 to 40 wpm internal B mode iambic keyer
Two (2) 63 character keyer memories.

Coax or balanced line output
Built in SWR indicator and BLT (balanced line tuner)

Size: 7.2" long, 4.2" wide, 1.5" high (less knob height)

Power supply voltage: 8 volts minimum, 12.5 volts maximum. 12 to 9 volts recommended
External power or internal battery pack

Paddle Bracket

Pictured with American Morse DCP Paddles

- Attaches to any PFR3 (including A and B versions)
- Works with any of the the American Morse DCP, Porta Paddle, Mini-B, and MS-2 kits
- Includes cable and all needed hardware

Supporting Files and Documents

PFR-3B Manual

Subscribe to the pfr3_group group

enter email address

Yahoo! Groups Join Now!

Powered by groups.yahoo.com

Ordering Information

To order this kit, use the buttons below. (you do not have to have a PayPal account to pay for items using a credit card)

NOTE
Use Add to cart buttons to add an item to your shopping cart. Use "Continue Shopping" tab to go back and add multiple items to your cart. You can view shipping charges before making payment. Payment can be made by Credit Card, Debit Card or by Paypal. Selecting "Checkout" in your shopping cart will allow you to use a credit card rather than Paypal Please be sure the address you supply is correct. We receive an automated notification when you complete payment. Your order will be shipped as soon as possible unless otherwise stated. Thanks for your support!

PFR3 Transceiver: 275.00 Add

PFR3 Bracket: $25.00 Add

PFR3 Bracket with DCP Paddles: $70.00 Add

View your shopping cart: Check Out

*Note: There is free shipping on the paddles when orderded with the **PFR3***

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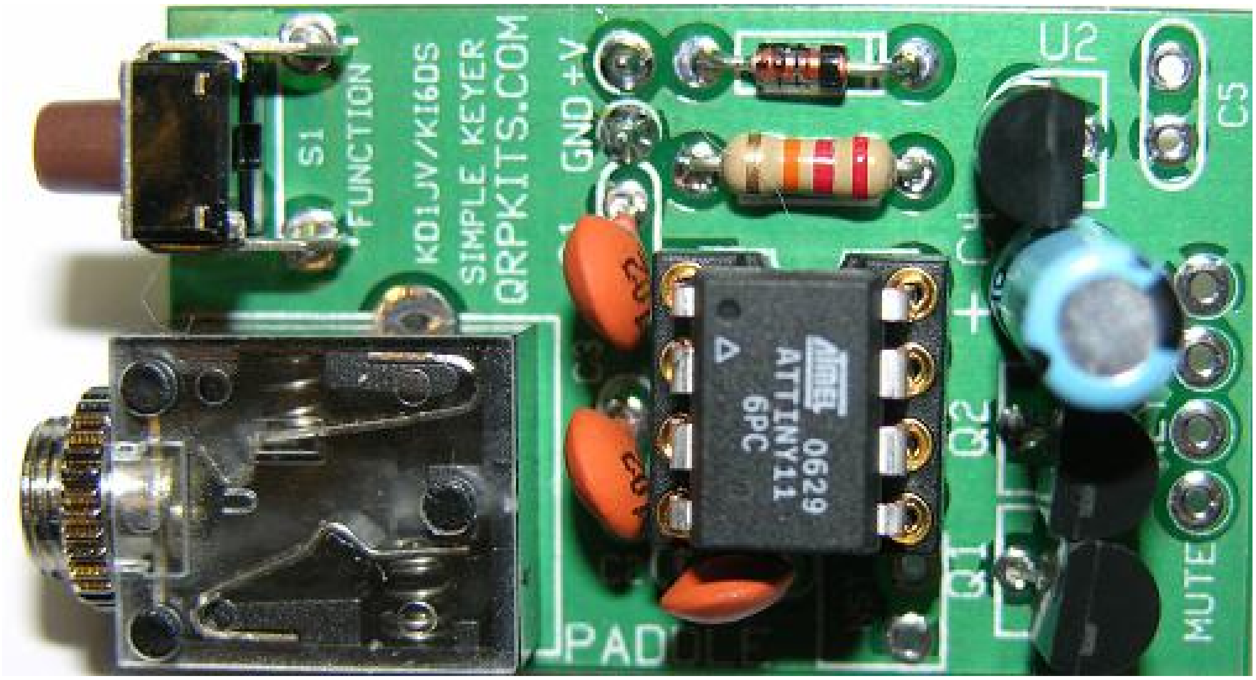
Page Maintained by: dean@alpinesoft.com

Pacific Antenna Return Policy

Pacific Antenna Simple Keyer Kit



Specifications and Features:

Speed range of 5 to 30 wpm

Operates in either iambic A or B mode, with B being the default

2 message memories

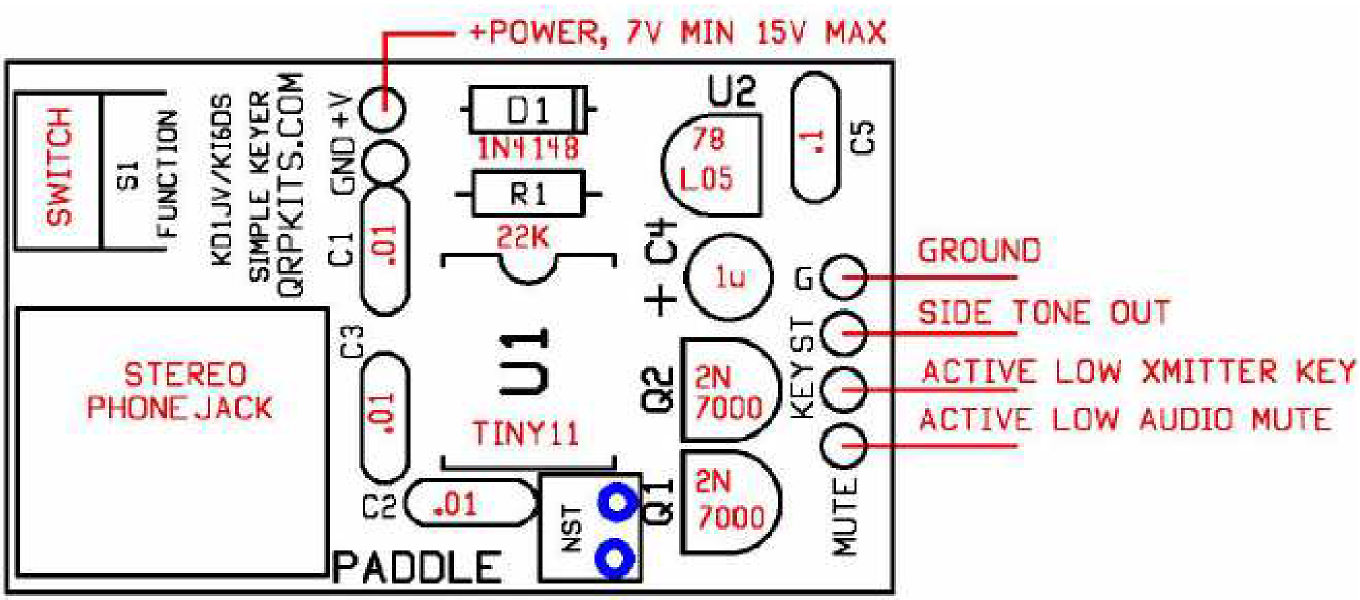
Tune and Beacon modes

Built on a 1 inch by 1.5 inch circuit board

Paddle jack can be used to mount the board or it can be remote mounted.

If panel mounted, only two holes needed

Parts Location Diagram:



Parts and Installation Sequence:

Install the following parts, making sure to check orientation with the diagram above and the board outline as they are installed

1) D1, 1N4148 glass diode, (match band end to board outline)
2) R1, 22K resistor Red/Red/Orange/Gold
3) 8 pin IC socket, (match to board outline)
4) C1, C2, C3 - .01uF (103) capacitor, (orientation does not matter)
5) Phone jack (only fits one way)
6) U2, 78L05 voltage regulator (match to board outline)
7) C4 – 1 uFd electrolyticcapacitor, (match board layout, + on board should be opposite – on capacitor
8) Q2, Q1 – 2N7000 MOSFET (match board layout)
9) C5 - .1 uFd (104) capacitor (orientation does not matter)
10) S1- Mode control switch, horizontal board mounted momentary switch.
11) Tiny13 microprocessor chip (match to board and socket notched end)

Connections:
The paddle jack is wired for “standard” paddle plug configuration of tip dot, ring dash, sleeve ground.

Key: This connects to the rigs straight key input and is active low.

Sidetone:
A Piezo electric speaker (not a buzzer!) can be directly connected to this output.
Note: A low impedance (8 - 32 ohm) dynamic speaker CAN NOT be directly connected.

If the keyer is built into a rig, the side tone can be injected into the rigs audio amp using a low pass filter to smooth out the square wave tone output to make it sound better and to reduce the amplitude from 5 volts peak to peak to something more reasonable. See the schematic on the last page for typical values.

If the rig uses a LM386, generally, one of the input pins is not used. This might be pin 2 or 3. Injecting the side tone (using the low pass filter) into the unused pin will produce volume control independent side tone level.

NST pads:
NST stands for No Side Tone. If your using the keyer with a rig which already generates side tone when transmitting, there is no need for the keyer to do it.

By putting a jumper between the NST pads, this will turn the side tone off when keying a rig. The side tone will still be active when the Function switch is used, as you need that audio feedback when using the switch.

Audio Mute output:
Most of the users of this keyer will not use the audio mute output. This output goes low (ground) before the key output does, and goes back high (open) about 7 milliseconds after the key output goes high (open).

The audio mute output is useful if you building the keyer into your own home brew rig, as it eliminates the R/C delay network normally required in the rigs audio mute circuit.

Using the NST jumper to turn the side tone off when keying will of course defeat the audio mute output. However, if your using the NST jumper, there is probably no need for the audio mute output.

Keyer operation:

The momentary switch is used to access the keyer functions.

Clicking and holding closed the switch for various lengths of time access these functions.

There are five possible functions which are selected using the “Function” Switch.

These are:

1. Send message
2. Set code speed
3. Enter and exit Tune Mode
4. Enter store message mode

Sending messages: (A message must be stored before this function will work)

After a short, quick click of the function switch, tap the Dot paddle to send message 1 or tap the Dash paddle to send message 2.

Once a message has started to be sent, it can be paused, stopped or set to beacon mode.
Note: only message 1 can be used for beacons.

Pause: Close and hold the Dash paddle.

Stop: Close and hold the Dot paddle.

NOTE: these actions will occur after a character currently being sent has finished sending.

Beacon mode:

Click and hold the function button as Message 1 is being sent.

The letter “B” will sound from the side tone when the mode is activated.

There is a fixed 3 second pause between repeating the message.

Closing either paddle during the pause will terminate beacon mode.

In addition, message Pause and Stop can be used during the sending of the message.

Change code speed:

A short, quick click of the switch enters change code speed mode.

There is a short pause to see if you want to send a message, then letter “S” will be sounded by the side tone.

Closing the Dash paddle will increase the code speed, a dot will sound incremented by 1 wpm increments

Closing the Dot paddle will decrease the code speed and a dot will sound each time the speed is decremented.

At the upper and lower speed limits, a double dot (I) will sound.

The change code speed mode will automatically exit after the paddles have been released for about 1 second.

Tune mode:

Tune mode is used when you want to key the transmitter continuously to say adjust an antenna tuner or make a power output measurement.

Click and hold closed the function switch until the letter “T” is sounded by the side tone (about 1 second)

To key the transmitter on, tap the Dash paddle closed.

To turn the transmitter off, tap the Dot paddle closed.

Repeat as needed.

To exit Tune mode and return to normal operation, click the Function switch.

Entering Messages:

Click and hold the function switch closed until the letter "M" is sounded by the side tone, about 1 second after the tune mode annunciation of "T".

A message of up to 29 characters (including word spaces) may now be entered via the paddle.

If you exceed the maximum character limit, "EM" will sound and you will have to start again, making the message shorter.

If you have a 2X3 call, you won't be able to quite fit a 3x3 CQ into the memory.

"Ideal" timing of 7 dot times for character space and 21 dot times for word spacing is used to determine the completion of a character or word space.

To insure a word space in inserted, it is best to pause slightly longer they you would otherwise between words.

Click the Function switch when you are finished entering the message.

The message will repeat so you can check for timing errors. If you need to re-enter the message, click the Function button and "EM" will sound.

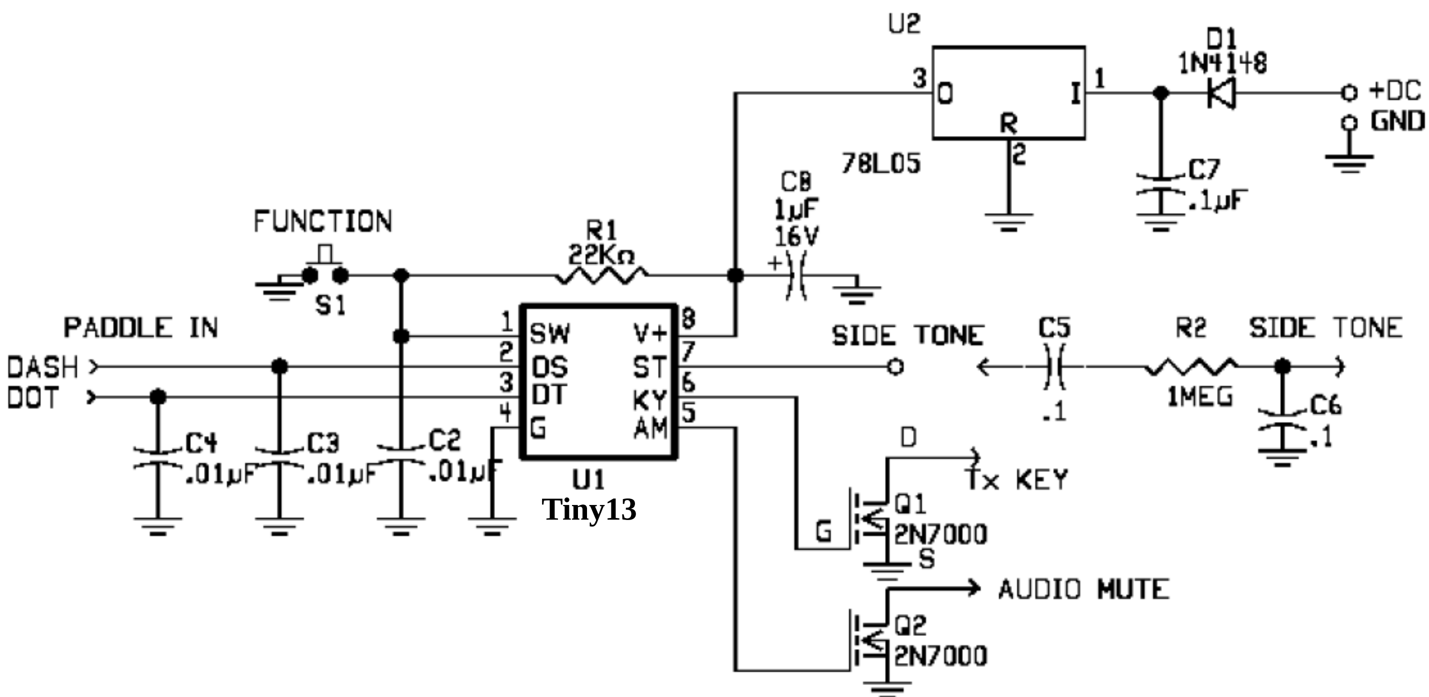
If the message was entered correctly, tap the Dot paddle to store the message in location 1 or the Dash paddle to store in location 2. "MS" (message stored) will sound and normal operation will resume.

Straight key mode:

If a mono plug is in the paddle jack at power up, the keyer will go into straight key mode.

In this mode, there is no need for the function switch, so it is disabled. This function allows using an external contest keyer if desired.

Schematic:

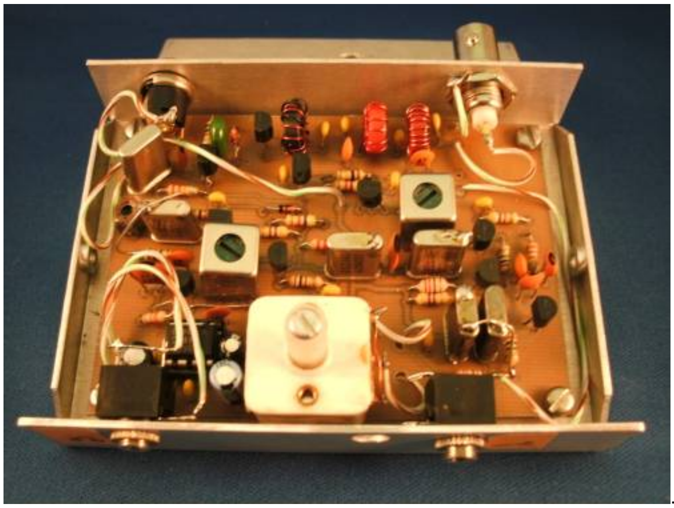


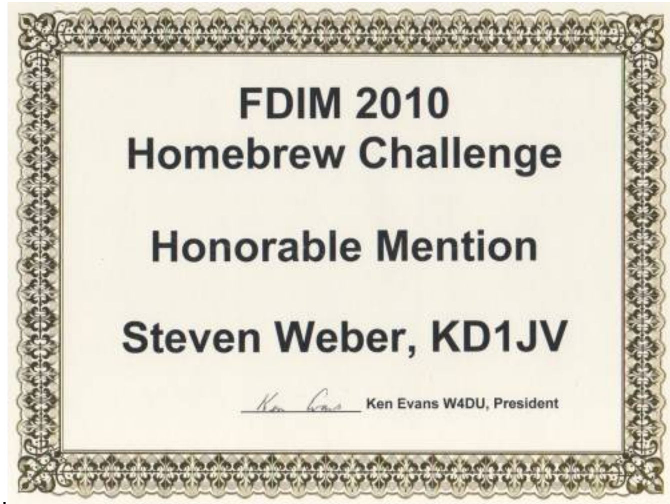
A CW transceiver for 30 Meters using 72 components

By KD1JV

For the spring 2010 FDIM (Four days in May) design contest, the ARCI (Amateur Radio Club International) decided on seeing if anyone could design a rig using 72 or less parts. What made this design a challenge was the fact the rig had to be a transceiver, the receiver had to have single signal reception and only 1 IC could be used. The design goal of my version was to come up with a reproducible design, using all common, easy to get and inexpensive parts. It also had to have a reasonably sensitive receiver and a transmitter with a bit more than flea power output. I meet these goals, the receiver having a MDS of about 0.5 uV - not great but usable - and a transmitter which puts out about 3/4 of a Watt. Nearly all the parts can be sourced from Mouser, the exception being the transmitter crystal and the toroid cores.

Five rigs were entered into the contest. I'm sorry to say my rig didn't win the contest (likely due to the receiver not working because of a lead shorting to the case I didn't notice after packaging it). I did however get an Honorable mention certificate.





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The Circuit:

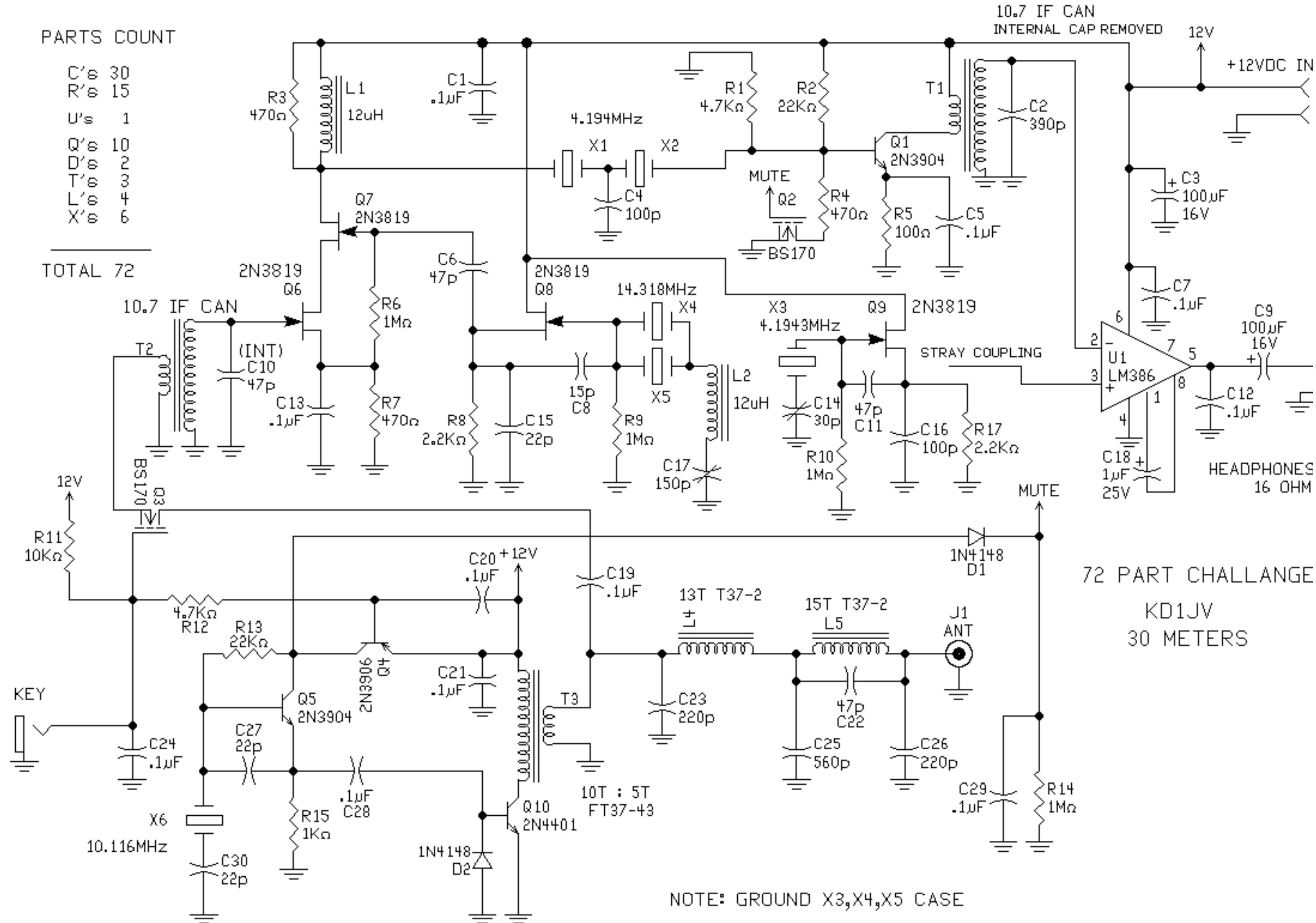
A number of different ideas for a receiver were tried before the final configuration was hit upon. It was quickly evident that making a rig with acceptable performance using only 72 parts was not going to be easy. I kept ending up with 80 to 90 parts. Everything finally came together after I hit upon the idea of using a LM386 as a combination product detector and audio amp. I'm not quite sure what made me think to try using a LM386 in such a fashion and was amazed when it actually worked! I'm not exactly sure how this works, but my theory is thus: If you look at the internal configuration of the LM386, you will see that the two input transistors share a common constant current sink. I believe the RF signals applied to the amplifier inputs are mixed in this current sink and the resulting audio beat note is amplified as if it were connected to one of the amplifier inputs. Some experimentation showed that the BFO signal had to be applied to non-inverting input pin 3 and had to be of very low amplitude. Therefore, pin 3 is left floating and stray coupling is used to inject the BFO signal. The amount of BFO injection is controlled by physically moving R17 closer or farther away from pin 3.

RF by-passing of the LM386 is important and must be done physically close to the chip. C18 across pins 1 and 8 improves the gain of the amplifier. MDS sensitivity of this product detector/audio amp is about 50 uV for a signal applied to the low impedance winding of T1.

The rest of the receiver is pretty standard. A super VXO provides pretty much full band tuning of 30M for the receiver. The mixer is comprised of series connected j-fets, which mimic a dual gate mosfet in operation. A simple two crystal, one cap IF filter provides reasonably good selectivity and opposite sideband suppression. An IF amplifier is required to get reasonably good sensitivity. Muting during transmit is achieved simply by using a MOSFET to switch a low value resistor to ground from the IF amplifier's base. This reduces the gain of the IF amp without completely turning it off. Side tone during transmit is achieved by tuning the receiver to the transmit frequency.

Because most of the 72 parts we were allowed to use are used up in the receiver, the transmitter had to be as simple as could be. This meant crystal control. Although directly keying the oscillator would have saved a few parts, using a PNP keying switch allows some wave shaping of the rise and fall time of the oscillator and simplifies controlling the QSK and mute switching. The single transistor output amplifier provides 700 mW of output power. The output

low pass filter attenuates all spurs to -50 dBc or better. This is achieved by adding C22 across L5, which makes a trap at the second harmonic.



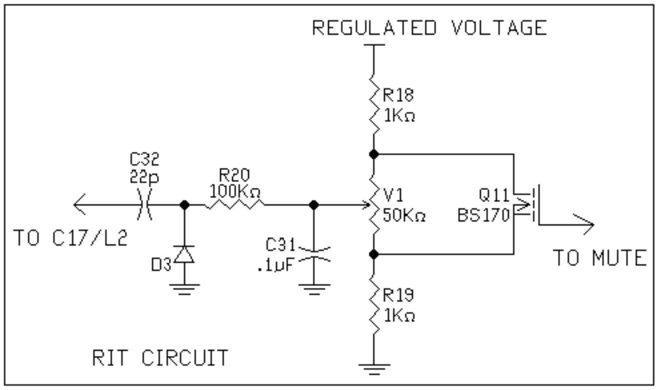
Improvements:

The schematic notes that the internal cap across the T1 secondary is removed and a 390 pfd cap used to tune the secondary to 4.194 MHz. This was done because if the internal cap was left in the IF can, it would have to have been counted as an individual part and that would have made the total 73 instead of 72. It really makes more sense to leave the cap in the IF transformer and use a 330 pfd cap to retune it instead.

2N7000's can be used instead of BS170's, but note that the Source and Drain pins are reversed between the two types. Therefore, when using 2N7000's, put them in the board 180 degrees from the part outline shown on the board.

Adding RIT would improve the usability of the rig significantly. This is easy enough to do and adds about 11 parts. Having RIT would allow keeping the receiver tuned to the transmit frequency to hear a side tone and allow tuning in another station which might not be exactly on your frequency. A suitable RIT circuit is shown below. The RIT voltage divider needs to be supplied with a regulated voltage. This could be either a zener diode and resistor or a three terminal regulator. A voltage of 8 to 9 volts would be suitable for the supply. The way this circuit works is during receive, Q11 is in an off state, allowing V1 to adjust the voltage across a tuning diode, D3. When the transmitter is keyed on, the mute voltage goes high and turns Q11 on, shorting out the RIT control, V1. The voltage across D3 is now centered at half the regulated voltage because R18 and R19 on either end of the RIT control are equal values.

No number is given for D3, as a number of different kinds of diodes will work, with varring degrees of tuning range. 1N4001 diodes will work, as will zeners with a reverse voltage of 20 or more volts. LED's also make good tuning diodes.



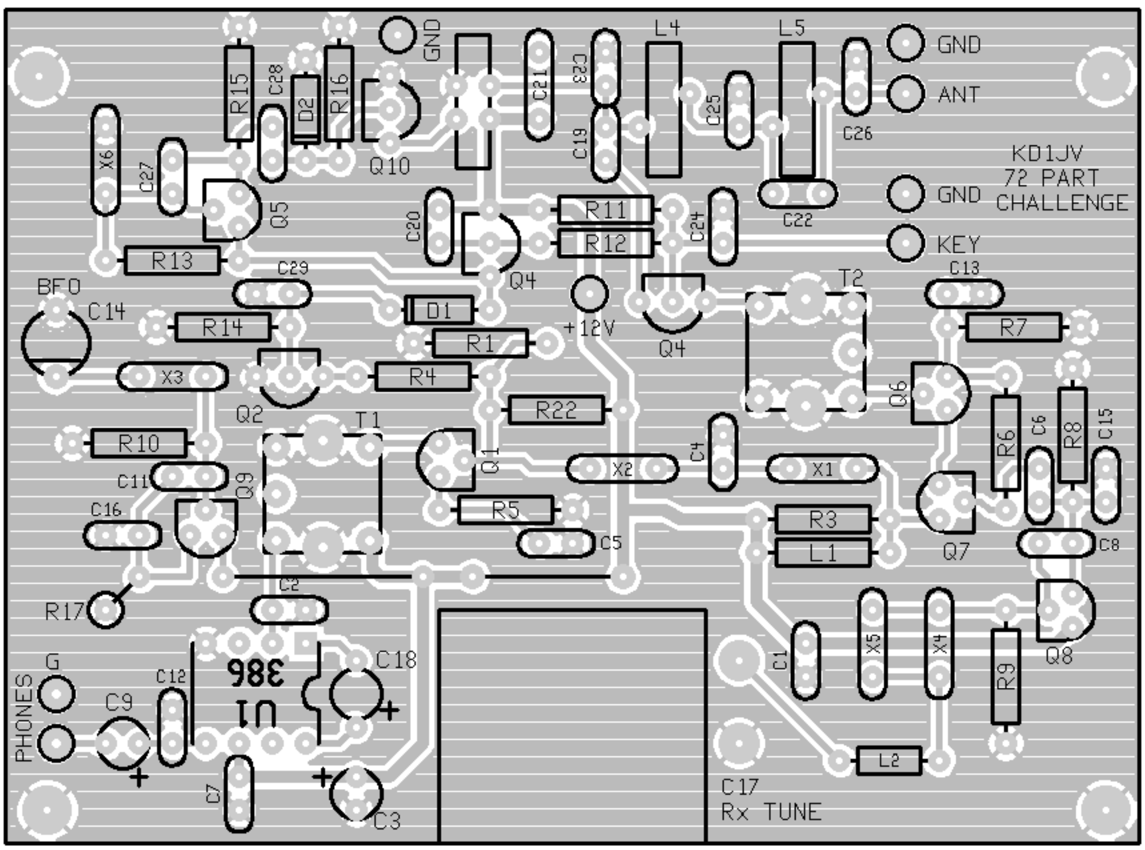
Construction:

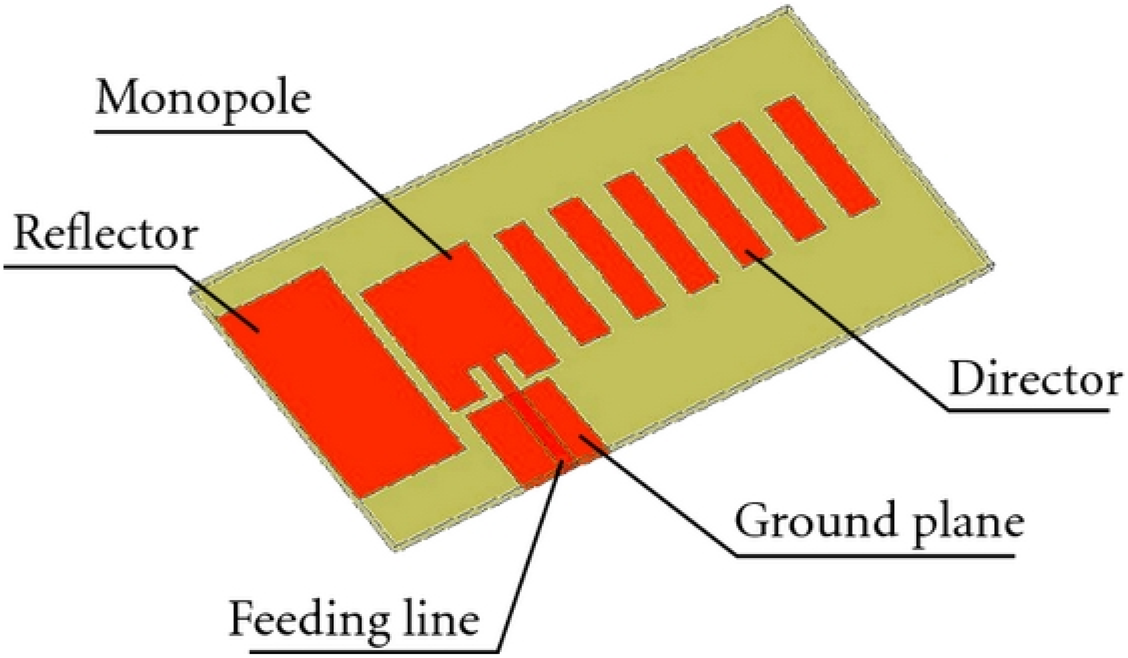
I built my rig on a pcb as shown. Dead bug on ground plane should work just as well. The tuning cap C17 is a polyvaricon, which can be taken out of a junk AM/FM radio or bought new from www.qrpkits.com. An air variable would work just a well (if not better, especially if it has a reduction drive built in) just being somewhat larger. A to scale board layout can be down loaded by [clicking here](). This is a through board view for directly printing on toner transfer film. The image gets reversed when you iron the print out onto the board.

Tune up:

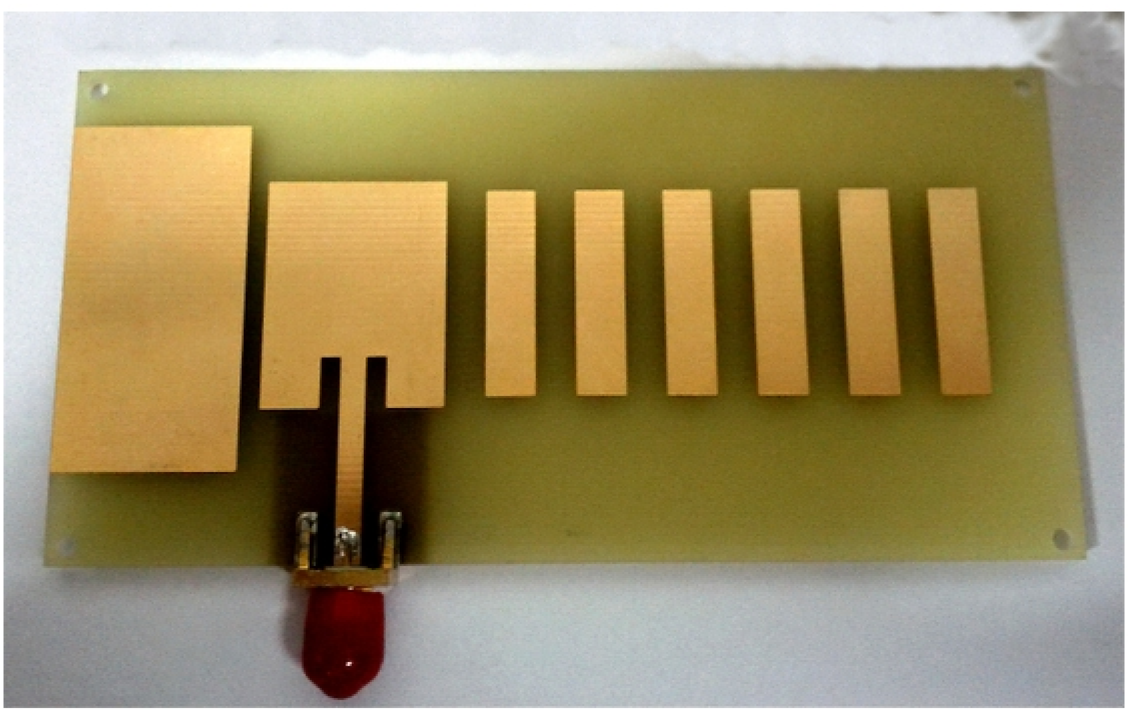
T1 and T2 will need to be adjusted for best receiver sensitivity. BFO trimmer C14 is adjusted for best opposite side band suppression. The position of R17 in respect to U1, the LM386 will affect receiver sensitivity. Tilt the resistor over towards U1 until a high pitch audio oscillation starts, then move the resistor away from the chip until the oscillation stops.

Parts layout: Actual size : 3.3" x 2.4"





(a) The structure of the quasi-Yagi antenna



(b) The photograph of the quasi-Yagi antenna

Figure 1: Compact broad-band quasi-Yagi antenna.

AMPLIFIER AND BIAS FOR THE CRYSTAL RECEIVER

(2003)

Amplifier and bias for the crystal receiver.

The LF amplifier

Much more stations can be received, louder and with a much better quality than with the crystal telephone. But it is intended for measurements and tuning purposes. When you cannot hear stations, it is impossible to adjust the antenna tuner.... With the amplifier, weak stations can already be heard when the antenna tuner is not set to maximum. Adjust the antenna tuner for maximum sensitivity and hope that you can also hear the station with the crystal telephone, without the LF amplifier.

The amplifier is also a nice extra option for comfortable listening with normal headphones to become familiar with the Medium Wave. Especially young people never have listened to the Medium Waves!

With the 20 meter long wire and after some experience, I do not need the LF amplifier for tuning adjustments anymore as there are always stations that can be heard with the crystal telephone. It is only used now for for comfortable listening with normal headphones and for measurement purposes.

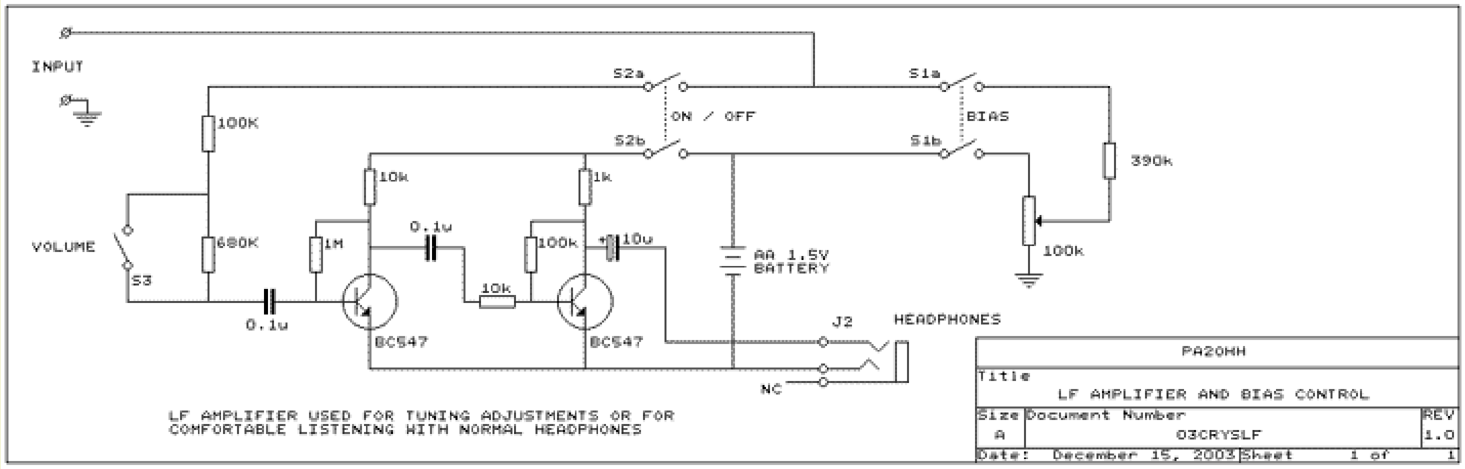


Diagram of the amplifier and bias control for the crystal receiver.
big diagram

Description
The gain of the LF amplifier is not very high, T1 is more an impedance matching circuit, gain is between 1.5 and 10x, depending on the position of S3, the simple volume control. In the low position, the high input impedance (680k resistor) hardly loads the detector.
Transistor T2 is the final amplifier and has a gain of 10x. The two earpieces of the headphones are connected in series instead of in parallel for extra audio output.
Battery life: 1 mA current, one AA cell is good for 2000 hours of use.
The bias circuit is switched on with S1 and the bias voltage is controlled by the 100 k potentiometer.

Inside view

Bias voltage control
The purpose of the bias voltage is to decrease the negative effect of the turn on voltage of the diode.
The effect of the bias voltage is rather unpredictable, sometimes it has a positive, sometimes a negative effect on the sensitivity of the receiver. It depends on the tap/top switch, frequency range etc. My general experience is that the positive effect is negligible in most situations, you can do without it. But sometimes it had a positive effect on the reception of weak stations and the audio quality of strong stations. Mostly there was a positive effect when the diode of the receiver was on the tap position and a negative effect when on the top position.

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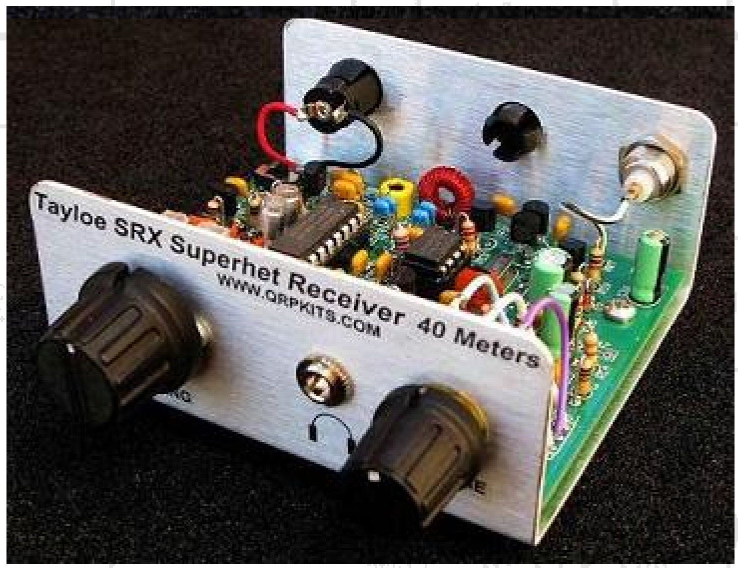
Simple Receiver



Specifications

As measured from current prototypes, some variance in performance is expected from unit to unit.

- Receiver Type: Superhet with a three crystal IF filter Receiver sensitivity: Better than -120 dBm
- Current Drain: ~ 17 mA at 12v.
  Features:
  - Bus switch first mixer improves handling of high level signal (40m SWBC!)
  - AGC - Automatically reduces large signals
  - 3 pole Crystal filter
    - Single sided receiver reception
    - Wider 500 Hz filter decreases "ringing" and listener fatigue
  - Audio gain chain incorporates active R/C low pass filter
    - Reduces unwanted high frequency audio gain stage hiss
    - Provides >30 dB additional attenuation for signals more than 2KHz away

- Headphone level output with diode limiting - o Protects your ears from static crashes or sudden strong stations
- Band coverage provided in two ranges
  - Each tuning range ~ 20 KHz wide
  - On board switch selects upper or lower band segments
    - 40m covers 7.000 to 7.022 and 7.024 to 7.049 MHz (DX and QRP segments)
    - 30m covers 10.100 to 10.120 MHz
- External "mute" input (active low)
  - Reduces receiver gain by ~ 70 dB
  - Receiver input protected to 5w when muted (only when muted!)

Manuals and other useful information

[Simple Receiver (SRX) Construction Manual (05/05/2013)](#)

Ordering Information

To order this kit, use the buttons below. (you do not have to have a PayPal account to pay for items using a credit card)

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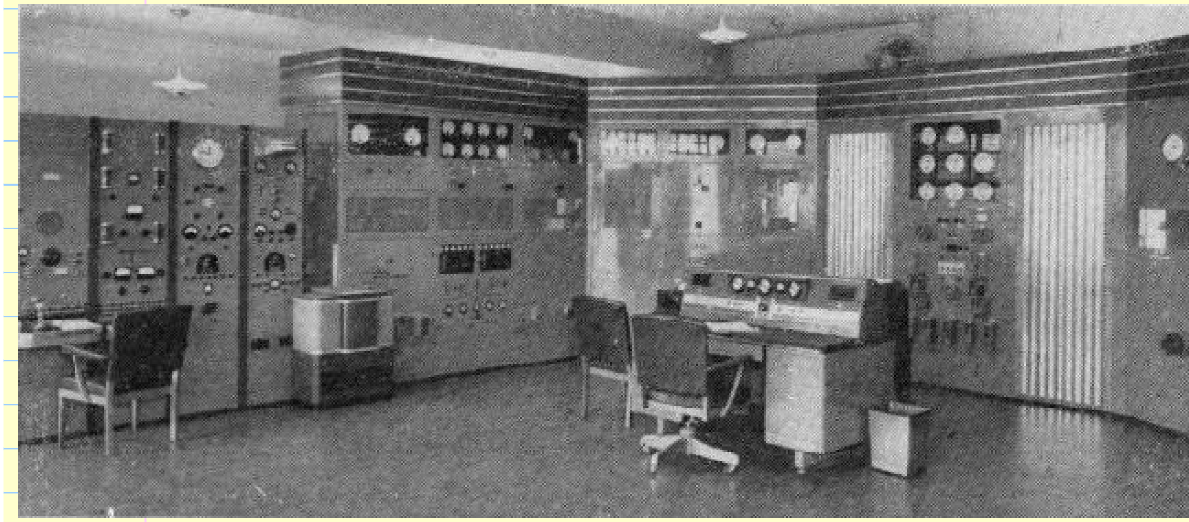
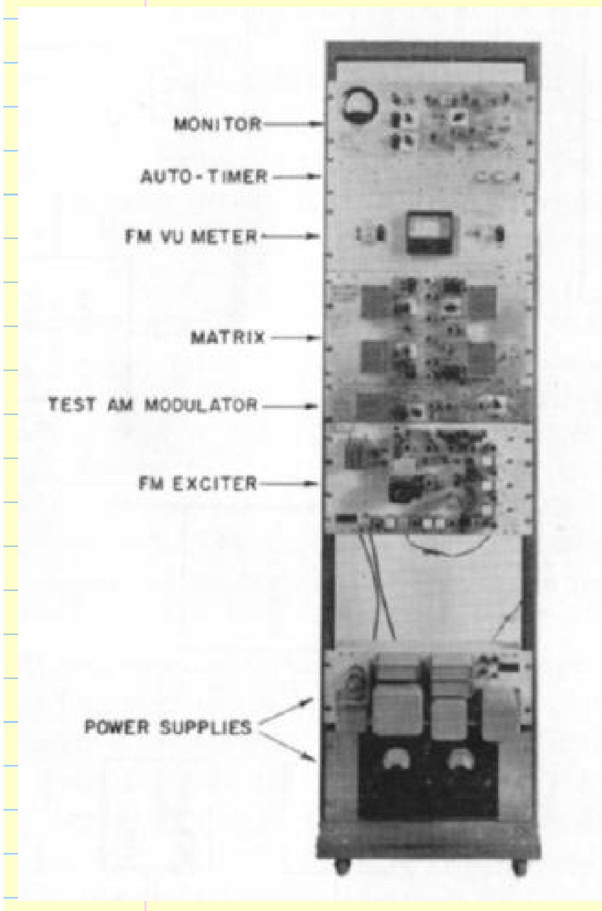
Pacific Antenna Return Policy

RCA's AM Stereo System, Circa 1959



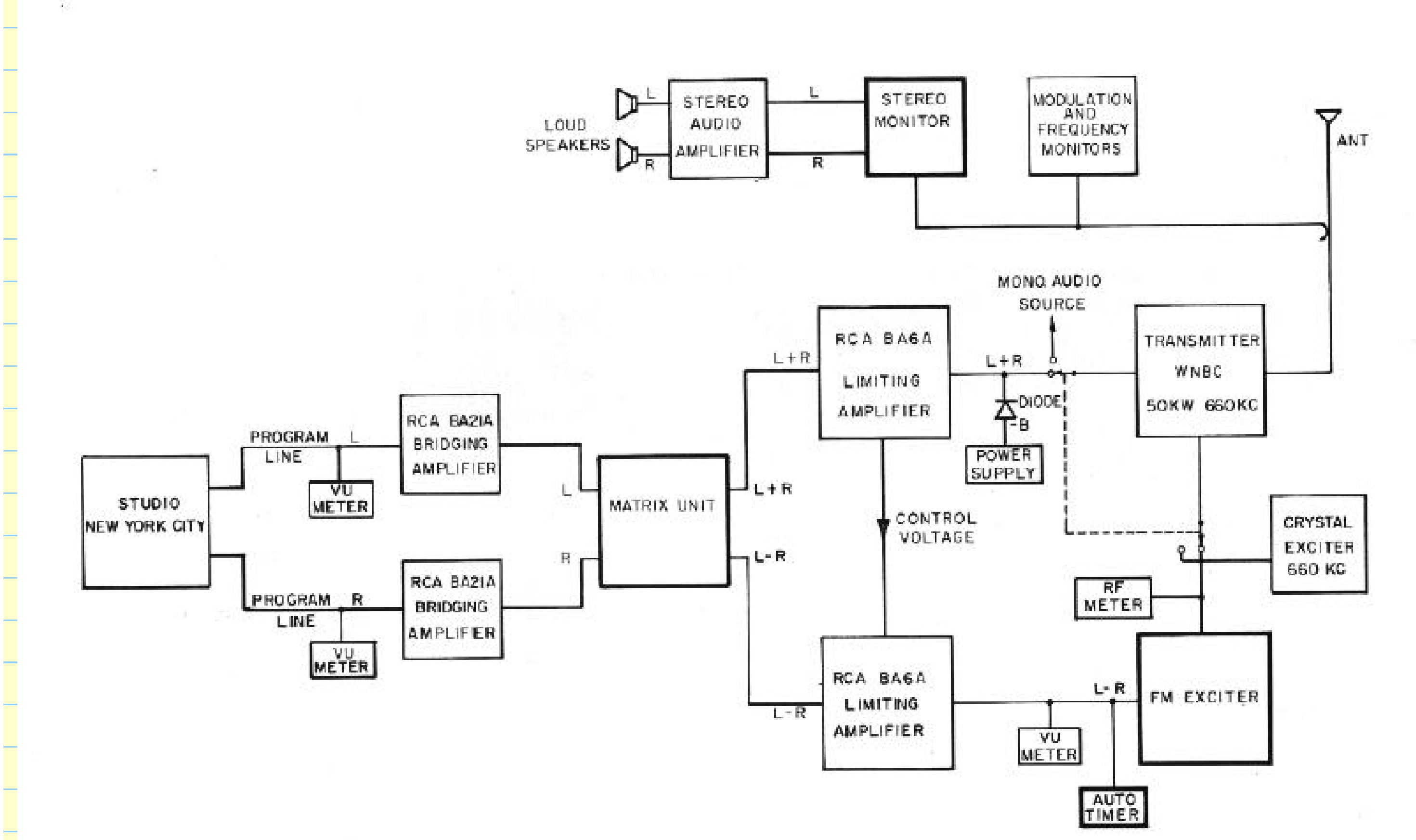


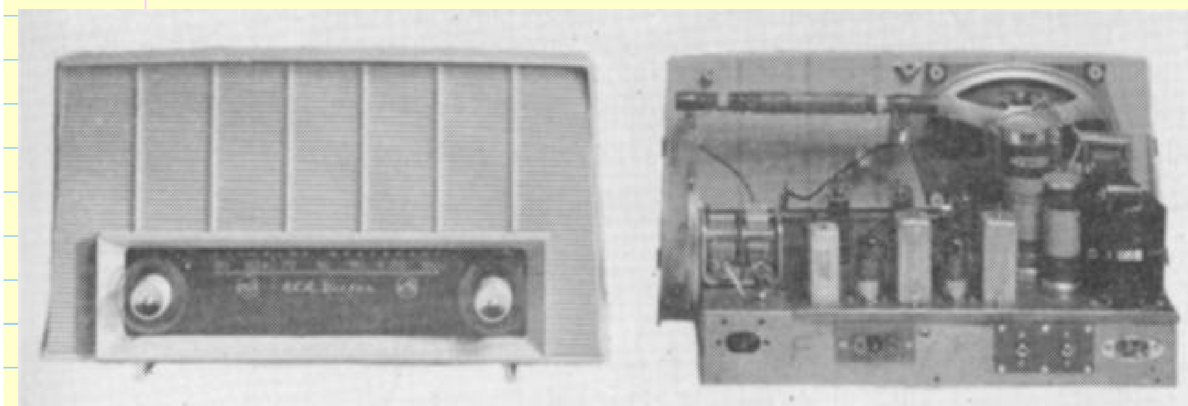
RCA developed an early AM Stereo system, and field tested it in 1959 on WNBC's 50 kW RCA-50B transmitter in New York. WNBC's RCA-50B transmitter, whose design dates back to 1930, is pictured in the 1940 photo shown above, when the station call letters were WEAF. The RCA AM stereo system transmits the L+R stereo sum signal as normal AM, and transmits the L-R stereo difference signal as FM on the main AM carrier. A deviation of about 1,000 Hz is used for the FM, and the L-R audio signal is pre-emphasized using a "modified" 100 usec. time constant.

To the left is a photo of the equipment rack holding the RCA AM Stereo equipment installed at the WNBC transmitter, to convert it for AM Stereo operation. Of special interest are the "Matrix", "FM Exciter", and "Monitor", which are explained below.

The block diagram below gives an overview of the operation of RCA's AM Stereo system. The Left and Right audio signals from the studio first pass through a "matrix" which changes them to a L+R stereo sum signal, and a L-R stereo difference signal. The L+R stereo sum signal is feed to the normal AM modulation input of the transmitter, through the customary limiting amplifier. Using the sum of the Left and Right audio signals to Amplitude Modulate the transmitter insures that a listener with a monophonic radio will receive a balanced, distortion free program. The "matrix" also includes a time delay circuit in the L+R signal path to compensate for the additional time delay the "FM exciter". The L-R signal is feed to the "FM exciter" through another limiting amplifier, whose gain control is slaved to the L+R limiter. The "FM exciter" uses a serrasoid modulator operating at a frequency of 110 kHz, which is one sixth of WNBC's final operating frequency of 660 kHz. After FM modulation, the 110 kHz signal passes through frequency multiplier stages which multiply its frequency by a factor of six, to the 660 kHz carrier frequency signal that drives the RCA-50B transmitter, in place of the original crystal oscillator unit. The "Monitor" is a high quality receiver/demodulator that is used to measure, and monitor, the performance of the AM Stereo transmitter.

To learn more about the legendary RCA 50B Transmitter, Click Here





This is a photo of a prototype AM Stereo Receiver built by RCA, to receive the 1959 AM Stereo Broadcasts on WNBC. This prototype AM Stereo Receiver is based on the chassis of an RCA Model XF-2 radio receiver. To view the schematic of the RCA AM Stereo Receiver, Click Here

I would be interested in hearing from anyone that has any additional information on the RCA AM Stereo system, and the field tests at WNBC in 1959. I can be reached by email at byrnsj@sbcglobal.net.

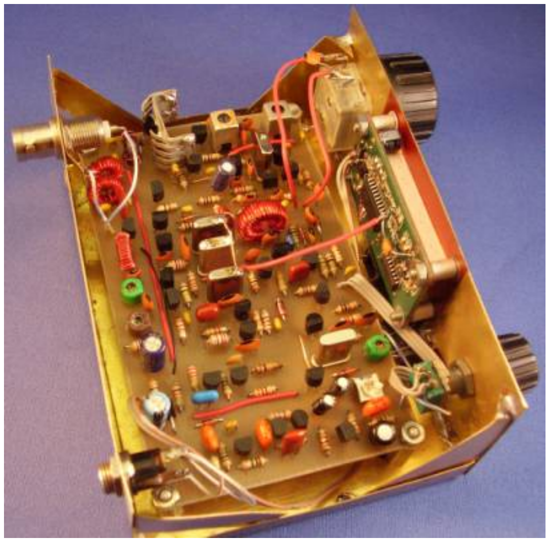
1/3/03

John's Home Page

The ADC-40

All Discrete Component transciever

Revised 6-23-09



When I was a little kid I asked my Dad, (who was a TV repairman), "If a 6 transistor radio works good, wouldn't a radio with 100 transistors work better?"

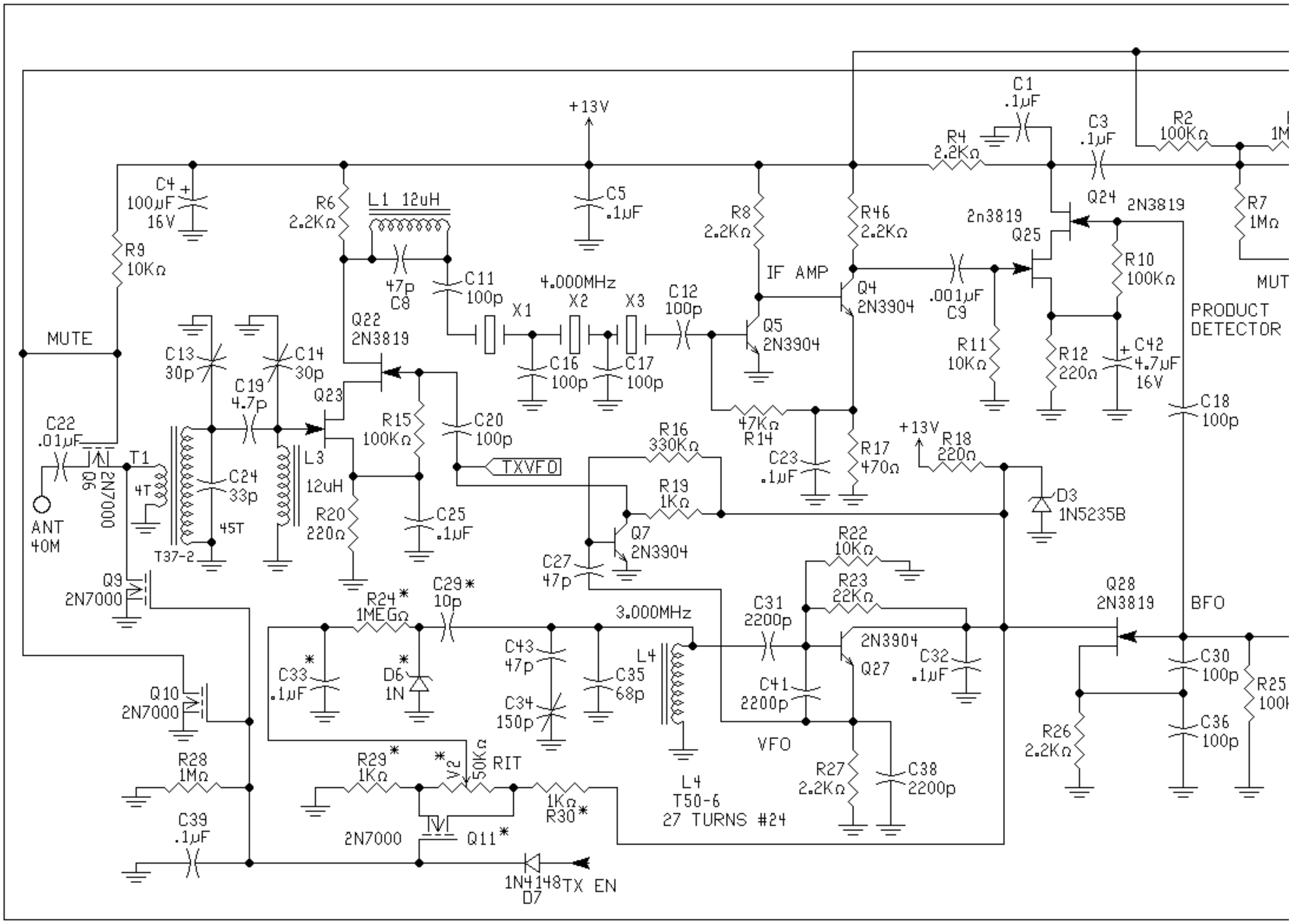
He simply answered, "Why use a 100 when 6 will do?". That was an important lesion for someone who was to go onto designing QRP radios. Of course, if you count the transistors used in highly intergrated IC's like microprocessors, DSP, and DDS chips often used in today's radios, the transistor count is in the millions. And these radios do work better than the old 6 transistor AM radios of the 60's.

The all discrete component transceiver described below is a throw back to yesterday, when we didn't have fancy IC's to work with. In the QRP sprit of "doing more with less" and the Minimum Art Session (MAS) DL contest of designing a functional rig with 100 parts or less, I set out to design a no IC, VFO tuned transceiver with super-het receiver with reasonably good performance. It quickly become apparent that a super-het receiver with good performance and a very low parts count were not compatible goals and the parts count quickly began to grow. Then once on air listening tests were started, using a good antenna, even more parts had to be added to keep strong SWBC stations from playing havic.

After all the solder smoke cleared, I found I had used over 80 componets in the receiver and some 40 more in the transmitter, for a total of 120+ componets. But it is a full feature receiver with RIT, audio mute, QSK switching on the input, .5 uV MDS (it takes a 1 uV signal to get Q5 copy) and good selectivity. The audio is very low noise and is almost silent without an antenna connected. The transmitter puts out a respectable 3 to 4 watts, depending on supply voltage. And it all fits on a 4" x 2.75" circuit board.

Receiver section schematic:

(diagrams can be printed by first saving to your PC by right clicking on the picture, then use a graphics viewing program to print the picture using scale to page option. If you try to print from the browser, only the part which shows up on the screen will print)



Value changes 6/25/09

Circuit description:

The Receiver section:

The signal from the antenna first passes through the QSK switch, C22 and Q6. Q6 is normally biased "ON" via resistor R9 and Q17 is "off". During transmit the gate of Q6 is pulled low via Q10 and Q6 is turned off, while Q9 is turned on, isolating the input to the receiver from the antenna. At the same time, the gate of Q26 is pulled low, muting the audio. R7 allows some audio to leak past Q26 for side tone. R3 and C10 delays the turn on time for Q23 to prevent audio thumps as the transmitter ramps down. Q17 had to be added to provide additonal isolation of the receiver input, as using only the series QSK switch Q6 allowed too much singal into the receiver and was causing transmitter instablility. This was likely due to the transmitter signal finding its way back into VFO via the 1st mixer. Q10 had to be added to provide isolation bewteen the receivers audio mute line and the transmitter keying transistor, as the AGC works with the audio mute circuit. A direct connection between the audio mute line and the transmitter key input caused the rig to "self key" when AGC action started. The gates of Q10, Q11 and Q9 are connected back to the transmitter keying transistor via diode D7, which casues these to turn on as soon as the transmitter is keyed. An R/C delay on the gates of these transistors keep them turned off for a short while after key up, allowing time for the transmitter signal to decay before turning RIT, audio and the antenna input connection to the receiver back on.

The receiver input is double tuned, using a link coupled toroid inductor and a RFC choke for the second inductor. The second tuned stage was found to be needed to reduce SWBC interference.

The first mixer is comprised of two J-FETs connected in series. These emulate a dual gate MOSFET in operation, with the input signal applied to the gate of the bottom FET and the VFO to the top FET. This is a slightly simplified version of the mixer as shown in "Experimental Methods in RF Design".

The mixer output then going through a 3 crystal filter for reasonable selectivity and opposite side band rejection. L1 and C8 form a trap at 7 MHz to keep strong SWBC stations from passing through the mixer (which has little isolation bewteen the input and output) from getting into the crystal filter and bleeding through.

The two transistor IF amp circuit was found in "Solid State Design for the Radio Amateur" and provides plenty of gain. Initially, a single transistor IF amp was tried, but overall receiver sensitivity was poor, despite also having a RF pre-amp and more audio gain.

The product detector uses the same dual J-FET mixer design as the 1st mixer, with C1 by-passing any RF present on the output of the mixer. The BFO signal if provided by Q28, which initally was a simpler oscillator. Unfortunately, the crystal frequency could not be pulled well enough to get it to provide a 600 Hz beat note, so a few additional parts had to be added.

The audio from the product detector passes through the audio mute switch, Q23, then into a high gain audio amp consisting of the darlington pair, Q2 and Q3. Q1 buffers the output of the audio amp so it can drive a fairly low impedance headphones. R21 reduces the amount of current flowing into the headphones and keeps Q1 from getting hot.

AGC: Earlier prototypes of this rig used a simple audio AGC signal to limit the amplitude of strong signals. I decided to remove the AGC system as it really wasn't all that effective. Instead, it was replaced by a simple volume control. The circuit board is laid out so either a volume control or a fixed resistor can be used. In the latter case, a headphone with in-line volume control would be used.

The VFO is a Colpits configuration with large value C feedback caps. C31, C41 and C38 should be polystyrine types for best results, though C0G caps could be used instead. This VFO is much more stable than the original VFO, which was a Hartley configuration using a J-FET. There was just enough drift in the original VFO circuit to be annoying.

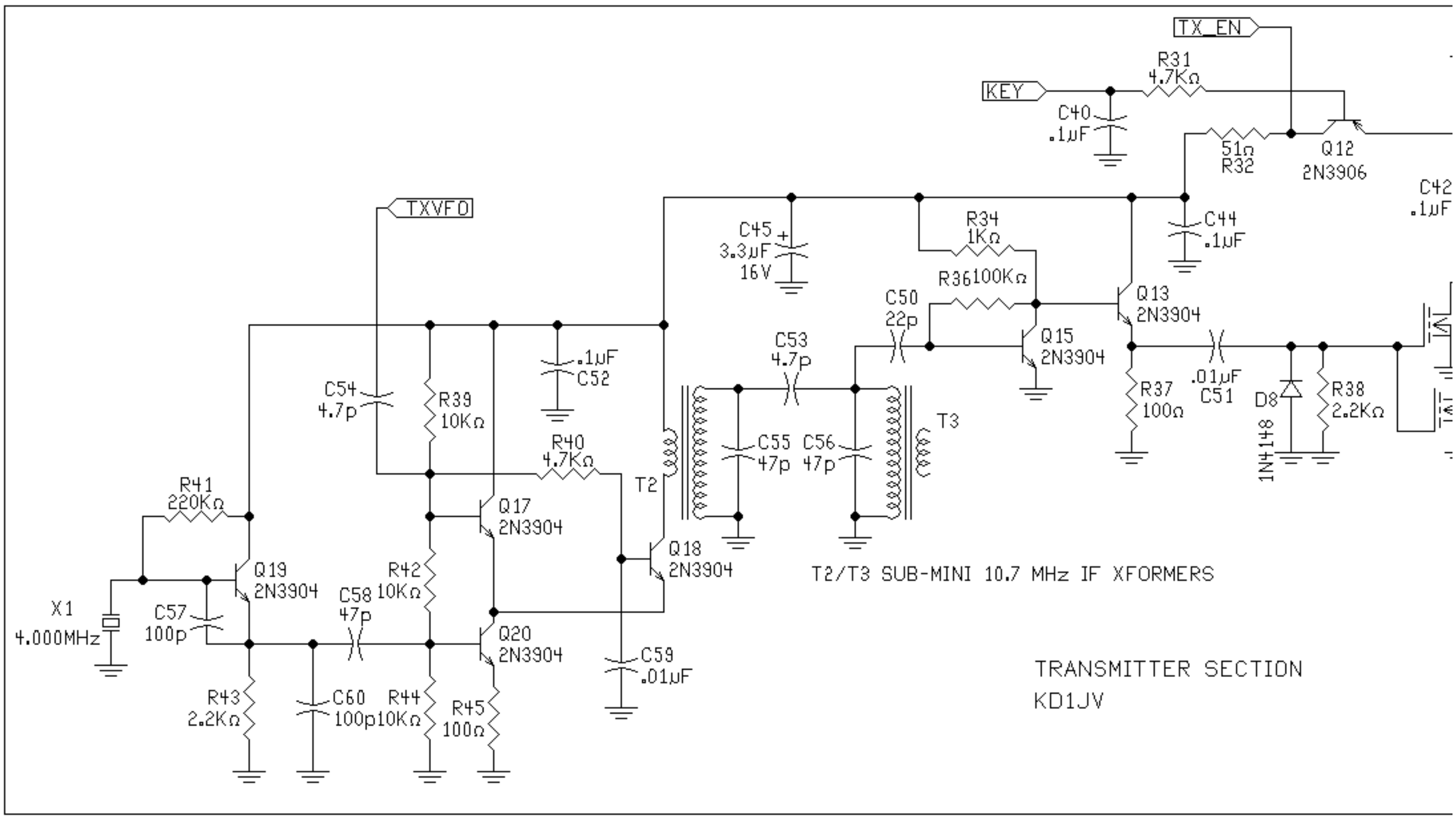
Q7 amplifies and buffers the VFO signal before going to the first mixer. This stage was found to be required as tuning the input tank circuit to the mixer would pull the VFO frequency and strong SWBC stations could cause the Digial Dial connected to actually jump around.

The VFO, BFO and AGC control pot voltages are regulated with a 6.8V zener diode, D3.

The schematic shows a single 50 pfd tuning cap, which would be ideally an air variable with reduction drive. The pcb board uses a poly-variable for board mounting and an additional cap, C30 to limit the tuning range. A value of 22 to 47 pfd would be used for C30 depending on how large a tuning range you'd like. I found when using the poly-variable for tuning, the tuning is non-linear. The first 50% of rotation changes the frequency by 15 kHz, but the second 50% changes it by 50 kHz, making the tuning a bit touchy at the higher end. I found a solution to this was to put a fixed value cap across the tuning cap. 22 pfd worked with the poly-variable, but of course, this reduces the tuning range.

Q11 is used to disable the RIT control by shorting it out. This causes R29 and R29 to bias the RIT tuning diode at the center voltage of the RIT control. The gate voltage for turning Q11 comes from the transmitter keying voltage.

Transmitter section:



Transmitter circuit discription:

The transmitter mixer gets its VFO signal from the Q7 VFO buffer to provent pulling of the VFO when the mixer is keyed.

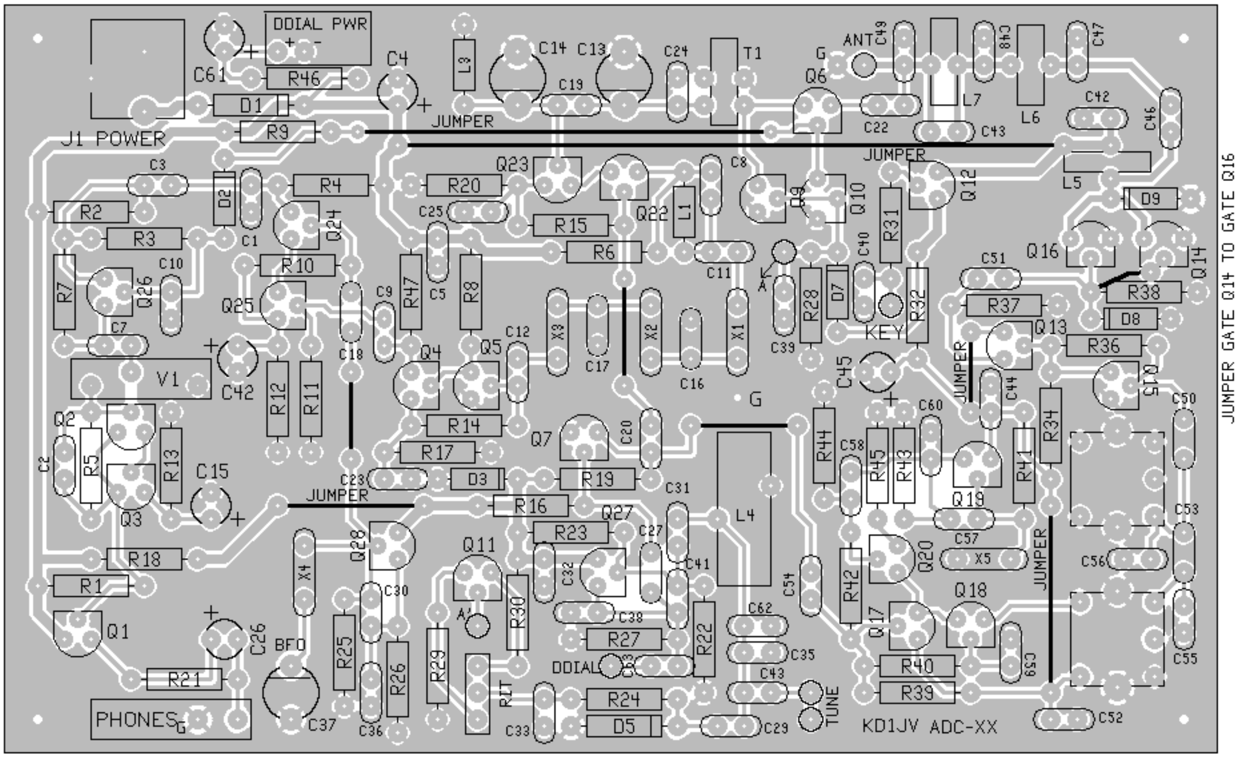
The BFO signal is provided by the cyrstal oscillator Q19. (NOTE: C57 and C60 should be made 47 pfd to better keep the transmit frequency the same as the receiver frequency) The mixer is a discrete implementation of the old CA3028 transistor array and provides a high level output. The mixer output is filtered by two 10.7 MHz IF cans, retuned for 40 M by the addition of 47p caps, C55 and C56. Mouser part number 42IF123-RC or 42IF122-RC can be used.

Ideally, the gates of the BS170 PA MOSFETs, Q14 and Q16 want to see a narrow signal with fast rise and fall times to work most effectively. Not having any logic gates to "square up" the signal driving the gates, we can only approximate this type of drive signal. Q15 is a non-linear amp being driven by the fairly large output signal from the transmitter band pass filter output. The output of Q15 is 6 V peak pulses at 7 MHz, which is then buffered by the emitter follower Q13. The buffer is required to keep the gate capacitance of thePA FETs from loading down the output of Q13 and drastically reducing the output.

The PA puts out about 4 watts with a 13.8 V supply. Because the drive is not ideal, these do get fairly warm. A small heatsink clipped across the PA transistors will keep the power out from droping as the PA gets hot. The drain break down voltage is also fairly low, 60 volts, so they can not tolerate high SWR conitions which can casuse the drain voltage to increase above 60 volts and to cause them to draw excessive current, resulting in thier distruction. Therefore, one needs to insure the load has a low SWR before transmitting! D9, not shown on the schematic but is on the circuit board, can be added to help protect the PA from high SWR voltages. (1N4753B, 47V 1W Zener)

The mixer and driver stages are keyed on by a PNP transistor, Q12. R32 and C45 provide an R/C time constant to ramp the keying voltage up and down to provent key clicks. The non-delayed keying voltage is taken from the collector of Q12 and sent to the receiver muting and QSK circuits.

PCB LAYOUT:



JUMPER PAD "A" TO "A" (GATE Q11 TO C39/R28/D7 JUNCTION)

Flood fill ground plane is used on the board layout to maximize the ground area. Care must be taken when etching the board to make sure the copper around the tracks and pads has been fully etched away. Also, do to the close proximity of the ground plane to tracks and pads, extra care must be taken when soldering in parts as to not make shorts to the ground. Using 0.020" solder instead of 0.032" solder is a big help in preventing solder shorts and using excessive solder.

Note the 6 point to point jumers indicated by the black lines. In addition, there is a long jumper across the board required to connect the pads labled "A" (the gate of Q11 to the C39/R23/D7 junction) Also a short jumper is needed to connect the gates of Q16 and Q14 together. Put this on the bottom of the board. This jumper was required as to not isolate the source connection of Q16 to the ground plane.

A pdf file with the board layout which will print to actual size can be down loaded by clicking [HERE](). This is a through board view and can be printed directly onto toner transfer film. The image gets reversed when you iron the pattern onto the board.

If you wish to add the Digital Dial, which also makes getting the VFO adjusted to the right frequency easier, they can be obtained from Hendricks Kits, http://www.qrpkits.com

R46 and C61 are not shown on the schematic and are used to filter the supply voltage to the digial dial. R46 is 100 ohms and C61 is 100 ufd. Without these parts, mulitplexing noise from the display gets into the receiver audio. Also, C63, a 10 pfd cap, is used to couple the VFO signal to the Digital dial counter input.

KD1JV

Deutsche Seiten

New Front Panel Design

- Components
- 40 m Band Superhet Receiver
- 40 m Band Direct Conversion Receiver
- 40 m Band Receiver without ICs
- Tx/Rx Control Circuit
- Some useful Tables
- 13.8 V / 15 A from a PC power supply
- 250 W S.M.P.S. with power FETs
- Power Supply for small Tube Amplifiers
- Calculating SWR meter
- Thermal Power Meter
- Analogue Frequency Display
- Selective AF Amplifier
- Simple IF Amplifier and Filter
- QRP push-pull RF amplifier
- 30 m Band Direct Conversion Receiver
- 80 m Band Direct Conversion Receiver
- 30 m Band QRP Transceiver
- AGC and S- Meter
- Oscillators
- Sidetone Circuits

- Guestbook
  - Sign in
  - View

- Guestbook Entries
  - in 2001
  - in 2000

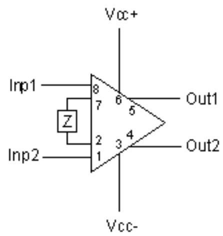
Guestbook commands:

- Eintragen (send entry)

NE592: Broadband Amplifier

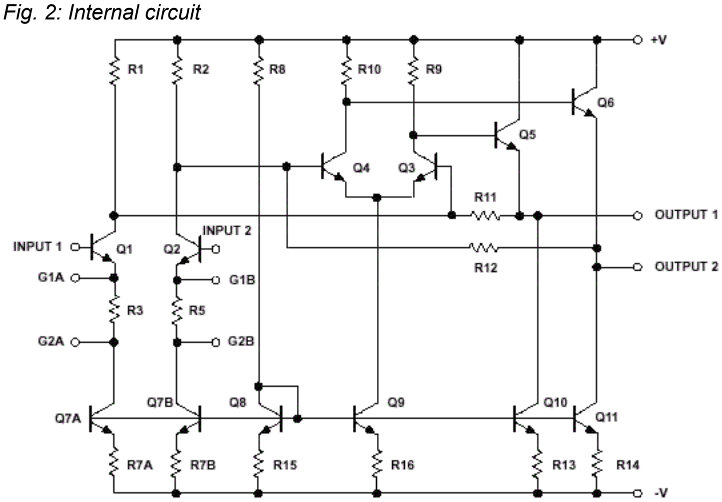
This broadband amp is intended as a video amplifier. It has a maximum gain of 400 (52 dB) and unity bandwidth of 120 MH

Fig. 1: Broadband amplifier NE592



Test circuits show that this component can self-oscillate depending on Z elements' placement, output loading, bias adjustm adjustment.

Fig. 2: Internal circuit



When placing the Z elements on the board, take care that they are located on the same side as the input pins. Placement

Tab.1: Absolute limits

Symbol	
Vcc	Supply voltage
Vin	Differential input voltage
Vcm	Common mode voltage
Iout	Output current
Ta	Operating temperature

DC data at Tu=25°C, VSS=+/-6 V and Vcm=0 V:

Symbol	
Avol	Differential gain
Rin	Input resistance at different gain adjustments by Radj
Vout	Differential output voltage
Icc	Supply current

A big advantage is that this broadband amplifier can be easily purchased. It costs less than 50 cents depending on the sup

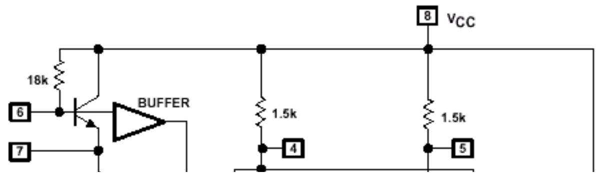
- Eintragen (send entry)
- Felder leeren (delete entry)

- Copyright

NE612: Mixer and Oscillator

You'll see the NE612 in homebrew projects very often. Functionally compatible with this type are the SA612/NE602 as well ring diode mixer. In applications such as a RX mixer, good pre-selection is strongly recommended. Intermodulation appear

Fig. 1: Internal Circuit



FELDHELL MACHINE FOR DOS PC AND CW TRANSMITTER

(2000)

Feld Hell program for DOS PC and CW transmitter.

The difference
This FELDHELL machine is intended for keying a CW transmitter. So it is different from the usual approach, connecting the soundcard to the microphone input of the SSB transmitter. The interface is connected to the LPT1 printer port and a transistor is keying your CW transmitter. The audio output of the receiver is connected to a simple A/D converter, constructed with simple ordinary electronic parts.
The DOS program is tested on and old PS2 (286) PC and it's speed was sufficient.
The advantages of this FELDHELL machine is that it can key your homemade CW QRP transmitter and that it is possible to transmit and receive at the same time. You can receive and decode your own transmitted signal. And for the rest you do not need a modern PC. If you have an old one somewhere, that will do the job.

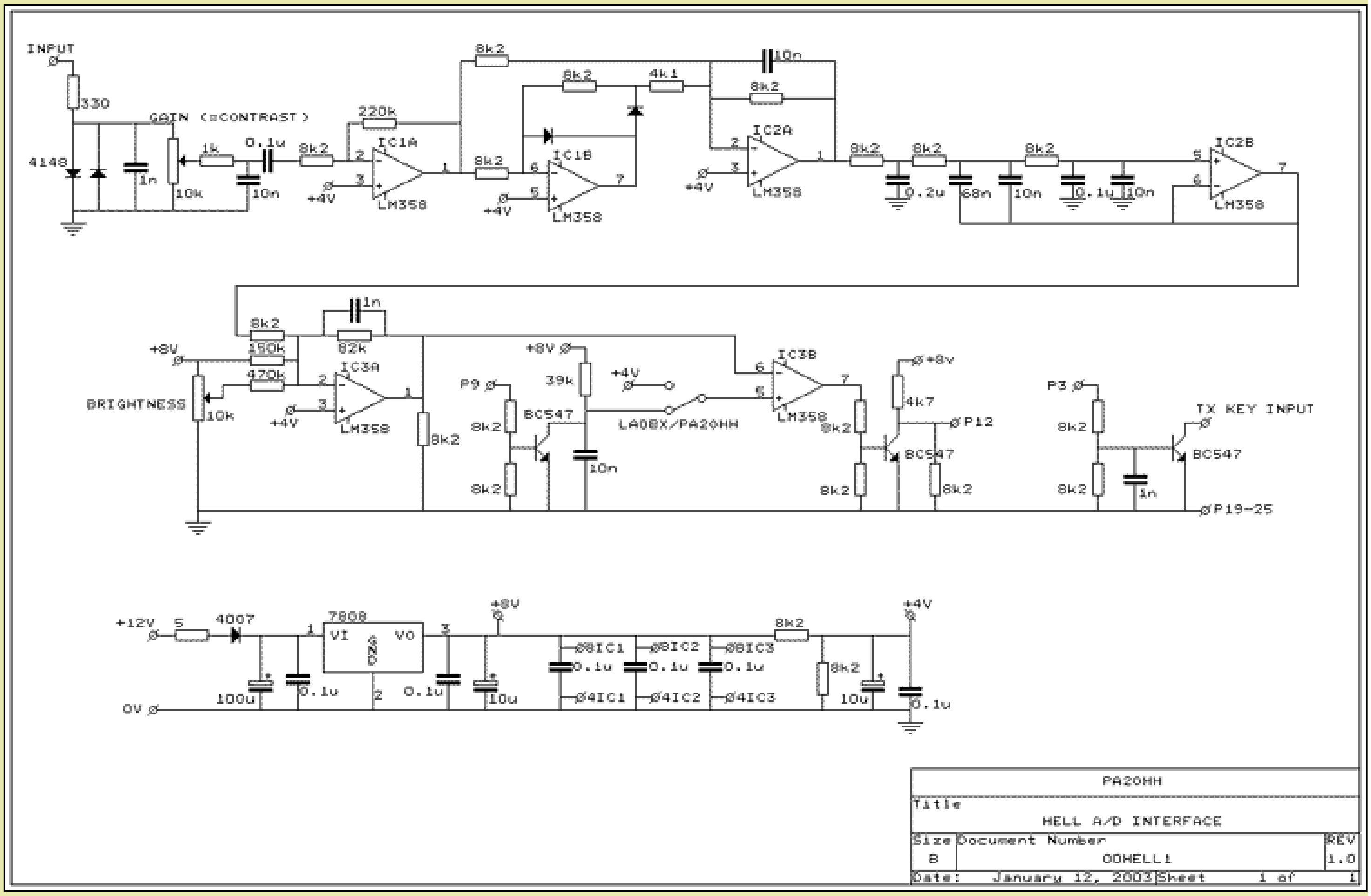
Working principle
The internal timer interrupt of the PC is used to transmit and receive with the correct symbol rate. This timer is also used for the D/A conversion.
IC1A amplifies the audio input signal. IC1B + IC2A are a double phase rectifier. IC2B is a lo pass filter for the detected signals. This signal is amplified by IC3A. The BC547 and IC3B are a simple A/D converter. The time to charge the 10nF capacitor to toggle comparator IC3B is measured by the PC's internal timer.
NOTE: The pins with the text Px refer to the pin numbers of the Centronics plug.

Running the program
Connect the HELL interface to LPT1 via a Centronics printer cable.
For accurate results, your PC should run in DOS mode, not in Windows. Start the program by typing HELL01.EXE. Read the Explanation of the program to find out how everything works.
You can run the program without any hardware. To see how the reception of signals works, activate the replay mode and replay the HELL001.HRX file that you can download as a ZIP file.

Download the software

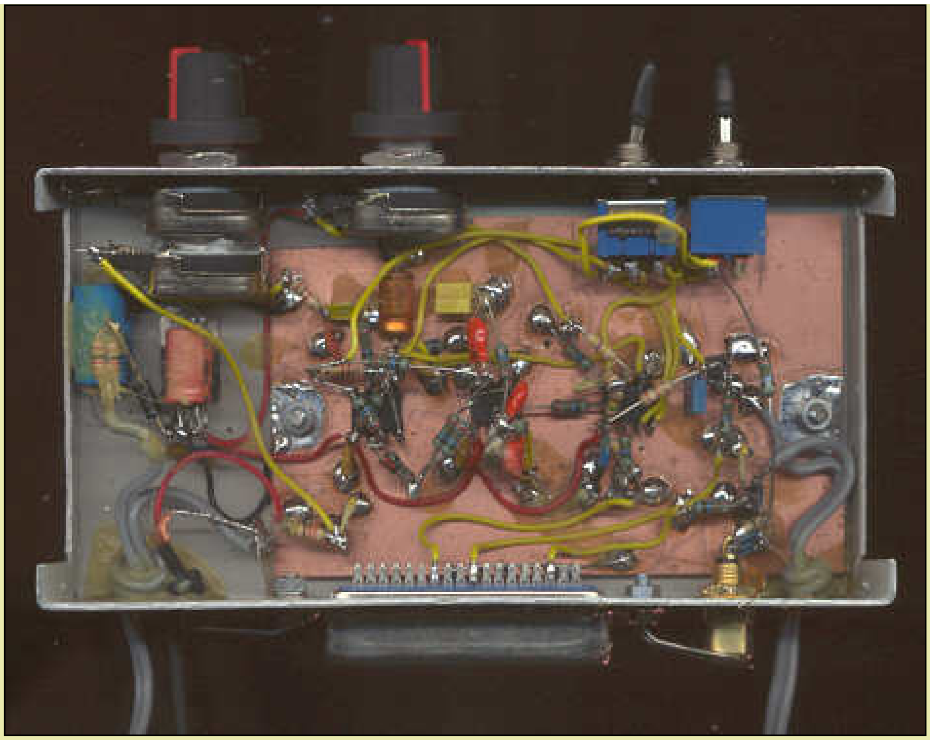
- HELL01A.ZIP (39k) containing HELL01.EXE DOS program.
- HELL01B.ZIP (15k) containing HELL01.C source code.
- HELL01C.ZIP (68k) containing EXAMPLE1.HRX and EXAMPLE2.HRX files for replay demonstration without hardware interface.

Example 1 is recorded while conditions were quite good.
Example 2 is with a lot of fast QSB and gives a good impression about reception of HELL signals under various conditions.



Circuit diagram
[big diagram](http://www.qsl.net/pa2ohh/fhell.htm)

The interface (there are some extra switches for other experiments)



Inside the box

BACK TO INDEX PA2OHH

Flower Pot "Hidden" Antenna

The Picture to the left is the Flower Pot antenna system that I built for a friend of mine who lives in one of the restrictive "Condos". It covers the 40, 20, 17, 12, and 10 meter bands using 4 inexpensive mobile whips of the "HAMSTICK " variety. Each antenna is switched onto the feedline by a simple and small relay control box that is mounted in the flower pot. The whips are mounted around the sides of the pot. Concrete was poured into the bottom to provide some Ballast.

The picture to the right is the flower pot antenna installed in it's final location at the CONDO. It remains pretty well hidden in plain site. If you want to build one of your own I Have made up a flowerpot.pdf file that shows how I made it and some construction hints. It can be viewed by clicking on the file name.

UPDATE: My friend Bruce W5PNQ who I made this antenna for told me that in the fall of 2006 he was able to work both Australia and New Zeland on 10 meters CW running 100 watts from his Kenwood TS-570. Not bad for a hidden antenna.

Return to Dave's Ham Radio Projects

Radio propagation

From Wikipedia, the free encyclopedia

Radio propagation is the behavior of radio waves as they travel, or are propagated, from one point to another, or into various parts of the atmosphere.[1] As a form of electromagnetic radiation, like light waves, radio waves are affected by the phenomena of reflection, refraction, diffraction, absorption, polarization, and scattering.[2]

Radio propagation is affected by the daily changes of water vapor in the troposphere and ionization in the upper atmosphere influenced by the Sun. Understanding the effects of varying conditions on radio propagation has many practical applications, from choosing frequencies for international shortwave broadcasters, to designing reliable mobile telephone systems, to radio navigation, to operation of radar systems.

Several different types of propagation are used in practical radio transmission systems. Line-of-sight propagation means radio waves which travel in a straight line from the transmitting antenna to the receiving antenna. It does not necessarily require a cleared sight path; at lower frequencies radio waves can pass through building walls and foliage. Line of sight transmission is used in short to medium range radio transmission such as garage door openers, cell phones, cordless phones, walkie-talkies, wireless networks, FM radio and television broadcasting and radar, and satellite communication, such as satellite television. Line-of-sight transmission on the surface of the Earth is limited to the distance to the visual horizon, about 40 miles. It is the only propagation method possible at microwave frequencies and above. At microwave frequencies moisture in the atmosphere (rain fade) can degrade transmission.

At lower frequencies in the MF, LF, and VLF bands, due to diffraction radio waves can bend over obstacles like hills, and travel beyond the horizon as surface waves which follow the contour of the Earth. These are called ground waves. AM broadcasting stations use ground waves to cover their listening areas. As the frequency gets lower the attenuation with distance decreases, so very low frequency (VLF) and extremely low frequency (ELF) ground waves can be used to communicate worldwide. VLF and ELF waves can penetrate significant distances through water and earth, and these frequencies are used for mine communication and military communication with submerged submarines.

At medium wave and shortwave frequencies (MF and HF bands) radio waves can reflect or refract from a layer of charged particles (ions) high in the atmosphere, called the ionosphere. So radio waves transmitted at an angle into the sky can be reflected back to Earth beyond the horizon, at great distances, even transcontinental distances. This is called skywave or "skip" propagation. It is used by amateur radio operators to talk to other countries, for diplomatic communications, and shortwave broadcasting stations that broadcast internationally. Skywave communication is variable, dependent on conditions in the upper atmosphere, and can be disrupted by events like solar flares, it is most reliable at night and in the winter. Due to its unreliability, since the advent of communication satellites in the 1960s many long range communication needs that previously used skywaves now use satellites.

In addition there are several less common radio propagation mechanisms, such as tropospheric scattering (troposcatter) and near vertical incidence skywave (NVIS) which are used in specialized communication systems.

Contents

Free space propagation

In free space, all electromagnetic waves (radio, light, X-rays, etc.) obey the inverse-square law which states that the power density of an electromagnetic wave is proportional to the inverse of the square of the distance from a point source[3] or:

$$\rho_P \propto \frac{1}{r^2}.$$

Doubling the distance from a transmitter means that the power density of the radiated wave at that new location is reduced to one-quarter of its previous value.

The power density per surface unit is proportional to the product of the electric and magnetic field strengths. Thus, doubling the propagation path distance from the transmitter reduces each of their received field strengths over a free-space path by one-half.

Modes

Radio frequencies and their primary mode of propagation

Band		Frequency	Wavelength	Propagation via
ELF	Extremely Low Frequency	3–30 Hz	10,000-100,000 km	
SLF	Super Low Frequency	30–300 Hz	10,000-1,000 km	
ULF	Ultra Low Frequency	0.3–3 kHz (300–3,000 Hz)	1,000–100 km	
VLF	Very Low Frequency	3–30 kHz (3,000–30,000 Hz)	100–10 km	Guided between the earth and the ionosphere.
LF	Low Frequency	30–300 kHz (30,000–300,000 Hz)	10–1 km	Guided between the earth and the D layer of the ionosphere. Surface waves.
MF	Medium Frequency	300–3000 kHz (300,000–3,000,000 Hz)	1000–100 m	Surface waves. E, F layer ionospheric refraction at night, when D layer absorption weakens.
HF	High Frequency (Short Wave)	3–30 MHz (3,000,000–30,000,000 Hz)	100–10 m	E layer ionospheric refraction. F1, F2 layer ionospheric refraction.
VHF	Very High Frequency	30–300 MHz (30,000,000–300,000,000 Hz)	10–1 m	Infrequent E ionospheric (E_s) refraction. Uncommonly F2 layer ionospheric refraction during high sunspot activity up to 50 MHz and rarely to 80 MHz. Generally direct wave. Sometimes tropospheric ducting or meteor scatter
UHF	Ultra High Frequency	300–3000 MHz (300,000,000–3,000,000,000 Hz)	100–10 cm	Direct wave. Sometimes tropospheric ducting.
SHF	Super High Frequency	3–30 GHz (3,000,000,000–30,000,000,000 Hz)	10–1 cm	Direct wave. Sometimes rain scatter.
EHF	Extremely High Frequency	30–300 GHz (30,000,000,000–300,000,000,000 Hz)	10–1 mm	Direct wave limited by absorption.
THF	Tremendously High frequency	0.3–3 THz (300,000,000,000–3,000,000,000,000 Hz)	1–0.1 mm	

Surface modes (groundwave)

Lower frequencies (between 30 and 3,000 kHz) have the property of following the curvature of the earth via -[groundwave] propagation in the majority of occurrences.

In this mode the radio wave propagates by interacting with the semi-conductive surface of the earth. The wave "clings" to the surface and thus follows the curvature of the earth. Vertical polarization is used to alleviate short circuiting the electric field through the conductivity of the ground. Since the ground is not a perfect electrical conductor, ground waves are attenuated rapidly as they follow the earth's surface. Attenuation is proportional to the frequency making this mode mainly useful for LF and VLF frequencies (see also Earth-ionosphere waveguide).

Today LF and VLF are mostly used for time signals, and for military communications, especially one-way transmissions to ships and submarines, although radio amateurs have an allocation at 137 kHz in some parts of the world. Radio broadcasting using surface wave propagation uses the higher portion of the LF range in Europe, Africa and the Middle East.

Early commercial and professional radio services relied exclusively on long wave, low frequencies and ground-wave propagation. To prevent interference with these services, amateur and experimental transmitters were restricted to the higher (HF) frequencies, felt to be useless since their ground-wave range was limited. Upon discovery of the other propagation modes possible at medium wave and short wave frequencies, the advantages of HF for commercial and military purposes became apparent. Amateur experimentation was then confined only to authorized frequency segments in that range.[4]

Direct modes (line-of-sight)

Line-of-sight is the direct propagation of radio waves between antennas that are visible to each other. This is probably the most common of the radio propagation modes at VHF and higher frequencies. Because radio signals can travel through many non-metallic objects, radio can be picked up through walls. This is still line-of-sight propagation. Examples would include propagation between a satellite and a ground antenna or reception of television signals from a local TV transmitter.

Ground plane reflection effects are an important factor in VHF line of sight propagation. The interference between the direct beam line-of-sight and the ground reflected beam often leads to an effective inverse-fourth-power ($1/\text{distance}^4$) law for ground-plane limited radiation. [Need reference to inverse-fourth-power law + ground plane. Drawings may clarify]

Ionospheric modes (skywave)

Skywave propagation, also referred to as skip, is any of the modes that rely on refraction of radio waves in the ionosphere, which is made up of one or more ionized layers in the upper atmosphere. F2-layer is the most important ionospheric layer for long-distance, multiple-hop HF propagation, though F1, E, and D-layers also play significant roles. The D-layer, when present during sunlight periods, causes significant amount of signal loss, as does the E-layer whose maximum usable frequency can rise to 4 MHz and above and thus block higher frequency signals from reaching the F2-layer. The layers, or more appropriately "regions", are directly affected by the sun on a daily diurnal cycle, a seasonal cycle and the 11-year sunspot cycle and determine the utility of these modes. During solar maxima, or sunspot

highs and peaks, the whole HF range up to 30 MHz can be used usually around the clock and F2 propagation up to 50 MHz is observed frequently depending upon daily solar flux 10.7cm radiation values. During solar minima, or minimum sunspot counts down to zero, propagation of frequencies above 15 MHz is generally unavailable.

Although the claim is commonly made that two-way HF propagation along a given path is reciprocal, that is, if the signal from location A reaches location B at a good strength, the signal from location B will be similar at station A because the same path is traversed in both directions. However, the ionosphere is far too complex and constantly changing to support the reciprocity theorem. The path is never exactly the same in both directions.[5] In brief, conditions at the two terminii of a path generally cause dissimilar polarization shifts, dissimilar splits into ordinary rays and extraordinary or *Pedersen rays* which are erratic and impossibly identical or similar due to variations in ionization density, shifting zenith angles, effects of the earth's magnetic DIPOLE contours, antenna radiation patterns, ground conditions and other variables.

Forecasting of skywave modes is of considerable interest to amateur radio operators and commercial marine and aircraft communications, and also to shortwave broadcasters. Real-time propagation can be assessed by listening for transmissions from specific beacon transmitters.

Meteor scattering

Meteor scattering relies on reflecting radio waves off the intensely ionized columns of air generated by meteors. While this mode is very short duration, often only from a fraction of second to couple of seconds per event, digital Meteor burst communications allows remote stations to communicate to a station that may be hundreds of miles up to over 1,000 miles (1,600 km) away, without the expense required for a satellite link. This mode is most generally useful on VHF frequencies between 30 and 250 MHz.

Auroral backscatter

Intense columns of Auroral ionization at 100 km altitudes within the auroral oval backscatter radio waves, perhaps most notably on HF and VHF. Backscatter is angle-sensitive—incident ray vs. magnetic field line of the column must be very close to right-angle. Random motions of electrons spiraling around the field lines create a Doppler-spread that broadens the spectra of the emission to more or less noise-like—depending on how high radio frequency is used. The radio-auroras are observed mostly at high latitudes and rarely extend down to middle latitudes. The occurrence of radio-auroras depends on solar activity (flares, coronal holes, CMEs) and annually the events are more numerous during solar cycle maxima. Radio aurora includes the so-called afternoon radio aurora which produces stronger but more distorted signals and after the Harang-minima, the late-night radio aurora (sub-storming phase) returns with variable signal strength and lesser doppler spread. The propagation range for this predominantly back-scatter mode extends up to about 2000 km in east-west plane, but strongest signals are observed most frequently from the north at nearby sites on same latitudes.

Rarely, a strong radio-aurora is followed by Auroral-E, which resembles both propagation types in some ways.

Sporadic-E propagation

Sporadic E (Es) propagation can be observed on HF and VHF bands.[6] It must not be confused with ordinary HF E-layer propagation. Sporadic-E at mid-latitudes occurs mostly during summer season, from May to August in the northern hemisphere and from November to February in the southern hemisphere. There is no single cause for this mysterious propagation mode. The reflection takes place in a thin sheet of ionisation around 90 km height. The ionisation patches drift westwards at speeds of few hundred km per hour. There is a weak periodicity noted during the season and typically Es is observed on 1 to 3 successive days and remains absent for a few days to reoccur again. Es do not occur during small hours; the events usually begin at dawn, and there is a peak in the afternoon and a second peak in the evening.[7] Es propagation is usually gone by local midnight.

Observation of radio propagation beacons operating around 28.2 MHz, 50 MHz and 70 MHz, indicates that maximum observed frequency (MOF) for Es is found to be lurking around 30 MHz on most days during the summer season, but sometimes MOF may shoot up to 100 MHz or even more in ten minutes to decline slowly during the next few hours. The peak-phase includes oscillation of MOF with periodicity of approximately 5...10 minutes. The propagation range for Es single-hop is typically 1000 to 2000 km, but with multi-hop, double range is observed. The signals are very strong but also with slow deep fading.

Tropospheric modes

Tropospheric scattering

At VHF and higher frequencies, small variations (turbulence) in the density of the atmosphere at a height of around 6 miles (10 km) can scatter some of the normally line-of-sight beam of radio frequency energy back toward the ground, allowing over-the-horizon communication between stations as far as 500 miles (800 km) apart. The military developed the White Alice Communications System covering all of Alaska, using this tropospheric scattering principle.

Tropospheric ducting

Sudden changes in the atmosphere's vertical moisture content and temperature profiles can on random occasions make microwave and UHF & VHF signals propagate hundreds of kilometers up to about 2,000 kilometers (1,300 mi)—and for ducting mode even farther—beyond the normal radio-horizon. The inversion layer is mostly observed over high pressure regions, but there are several tropospheric weather conditions which create these randomly occurring propagation modes. Inversion layer's altitude for non-ducting is typically found between 100 meters (300 ft) to about 1 kilometer (3,000 ft) and for ducting about 500 meters to 3 kilometers (1,600 to 10,000 ft), and the duration of the events are typically from several hours up to several days. Higher frequencies experience the most dramatic increase of signal strengths, while on low-VHF and HF the effect is negligible. Propagation path attenuation may be below free-space loss. Some of the lesser inversion types related to warm ground and cooler air moisture content occur regularly at certain times of the year and time of day. A typical example could be the late summer, early morning tropospheric enhancements that bring in signals from distances up to few hundred kilometers for a couple of hours, until undone by the Sun's warming effect.

Tropospheric delay

This is a source of error in radio ranging techniques, such as the Global Positioning System (GPS).[8] See also the page of GPS meteorology.

Rain scattering

Rain scattering is purely a microwave propagation mode and is best observed around 10 GHz, but extends down to a few gigahertz—the limit being the size of the scattering particle size vs. wavelength. This mode scatters signals mostly forwards and backwards when using horizontal polarization and side-scattering with vertical polarization. Forward-scattering typically yields propagation ranges of 800 km. Scattering from snowflakes and ice pellets also occurs, but scattering from ice without watery surface is less effective. The most common application for this phenomenon is microwave rain radar, but rain scatter propagation can be a nuisance causing unwanted signals to intermittently propagate where they are not anticipated or desired. Similar reflections may also occur from insects though at lower altitudes and shorter range. Rain also causes attenuation of point-to-point and satellite microwave links. Attenuation values up to 30 dB have been observed on 30 GHz during heavy tropical rain.

Airplane scattering

Airplane scattering (or most often reflection) is observed on VHF through microwaves and, besides back-scattering, yields momentary propagation up to 500 km even in mountainous terrain. The most common back-scatter applications are air-traffic radar, bistatic forward-scatter guided-missile and airplane-detecting trip-wire radar, and the US space radar.

Lightning scattering

Lightning scattering has sometimes been observed on VHF and UHF over distances of about 500 km. The hot lightning channel scatters radio-waves for a fraction of a second. The RF noise burst from the lightning makes the initial part of the open channel unusable and the ionization disappears quickly because of recombination at low altitude and high atmospheric pressure. Although the hot lightning channel is briefly observable with microwave radar, no practical use for this mode has been found in communications.

Other effects

Diffraction

Knife-edge diffraction is the propagation mode where radio waves are bent around sharp edges. For example, this mode is used to send radio signals over a mountain range when a line-of-sight path is not available. However, the angle cannot be too sharp or the signal will not diffract. The diffraction mode requires increased signal strength, so higher power or better antennas will be needed than for an equivalent line-of-sight path.

Diffraction depends on the relationship between the wavelength and the size of the obstacle. In other words, the size of the obstacle in wavelengths. Lower frequencies diffract around large smooth obstacles such as hills more easily. For example, in many cases where VHF (or higher frequency) communication is not possible due to shadowing by a hill, it is still possible to communicate using the upper part of the HF band where the surface wave is of little use.

Diffraction phenomena by small obstacles are also important at high frequencies. Signals for urban cellular telephony tend to be dominated by ground-plane effects as they travel over the rooftops of the urban environment. They then diffract over roof edges into the street, where multipath propagation, absorption and diffraction phenomena dominate.

Absorption

Low-frequency radio waves travel easily through brick and stone and VLF even penetrates sea-water. As the frequency rises, absorption effects become more important. At microwave or higher frequencies, absorption by molecular resonances in the atmosphere (mostly from water, H_2O and oxygen, O_2) is a major factor in radio propagation. For example, in the 58–60 GHz band, there is a major absorption peak which makes this band useless for long-distance use. This phenomenon was first discovered during radar research in World War II. Above about 400 GHz, the Earth's atmosphere blocks most of the spectrum while still passing some - up to UV light, which is blocked by ozone - but visible light and some of the near-infrared is transmitted. Heavy rain and falling snow also affect microwave absorption.

Measuring HF propagation

HF propagation conditions can be simulated using radio propagation models, such as the Voice of America Coverage Analysis Program, and realtime measurements can be done using chirp transmitters. For radio amateurs the WSPR mode provides maps with real time propagation conditions between a network of transmitters and receivers.[9] Even without special beacons the realtime propagation conditions can be measured: a worldwide network of receivers decodes morse code signals on amateur radio frequencies in realtime and provides sophisticated search functions and propagation maps for every station received.[10]

Practical effects

The average person can notice the effects of changes in radio propagation in several ways.

In AM broadcasting, the dramatic ionospheric changes that occur overnight in the mediumwave band drive a unique broadcast license scheme, with entirely different transmitter power output levels and directional antenna patterns to cope with skywave propagation at night. Very few stations are allowed to run without modifications during dark hours, typically only those on clear channels in North America. Many stations have no authorization to run at all outside of daylight hours. Otherwise, there would be nothing but interference on the entire broadcast band from dusk until dawn without these modifications.

For FM broadcasting (and the few remaining low-band TV stations), weather is the primary cause for changes in VHF propagation, along with some diurnal changes when the sky is mostly without cloud cover. These changes are most obvious during temperature inversions, such as in the late-night and

early-morning hours when it is clear, allowing the ground and the air near it to cool more rapidly. This not only causes dew, frost, or fog, but also causes a slight "drag" on the bottom of the radio waves, bending the signals down such that they can follow the Earth's curvature over the normal radio horizon. The result is typically several stations being heard from another media market — usually a neighboring one, but sometimes ones from a few hundred kilometers away. Ice storms are also the result of inversions, but these normally cause more scattered omnidirection propagation, resulting mainly in interference, often among weather radio stations. In late spring and early summer, a combination of other atmospheric factors can occasionally cause skips that duct high-power signals to places well over 1000km away.

Non-broadcast signals are also affected. Mobile phone signals are in the UHF band, ranging from 700 to over 2600 Megahertz, a range which makes them even more prone to weather-induced propagation changes. In urban (and to some extent suburban) areas with a high population density, this is partly offset by the use of smaller cells, which use lower effective radiated power and beam tilt to reduce interference, and therefore increase frequency reuse and user capacity. However, since this would not be very cost-effective in more rural areas, these cells are larger and so more likely to cause interference over longer distances when propagation conditions allow.

While this is generally transparent to the user thanks to the way that cellular networks handle cell-to-cell handoffs, when cross-border signals are involved, unexepected charges for international roaming may occur despite not having left the country at all. This often occurs between southern San Diego and northern Tijuana at the western end of the U.S./Mexico border, and between eastern Detroit and western Windsor along the U.S./Canada border. Since signals can travel unobstructed over a body of water far larger than the Detroit River, and cool water temperatures also cause inversions in surface air, this "fringe roaming" sometimes occurs across the Great Lakes, and between islands in the Caribbean. Signals can skip from the Dominican Republic to a mountainside in Puerto Rico and vice versa, or between the U.S. and British Virgin Islands, among others. While unintended cross-border roaming is often automatically removed by mobile phone company billing systems, inter-island roaming is typically not.

See also

- Diversity scheme
- Earth bulge
- Earth-ionosphere waveguide
- Electromagnetic radiation
- Fading
- Fresnel zone
- Free space
- Inversion (meteorology)
- Kennelly–Heaviside layer
- Near and far field
- Radio atmospherics
- Radio frequency
- Radio horizon
- Radio propagation model

- Rayleigh fading
- Ray tracing (physics)
- Schumann resonance
- Skip (radio)
- Skip zone
- Skywave
- Tropospheric propagation
- TV and FM DX
- Upfade
- VOACAP - Free professional HF propagation prediction software
- Critical frequency

References

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2. Demetrius T Paris and F. Kenneth Hurd, *Basic Electromagnetic Theory*, McGraw Hill, New York 1969 ISBN 0-07-048470-8, Chapter 8
3. Westman *Reference data* page 26-19
4. Clinton B. DeSoto (1936). *200 meters & Down - The Story of Amateur Radio*. W. Hartford, CT: The American Radio Relay League. pp. 132–146. ISBN 0-87259-001-1.
5. G.W. Hull, "Nonreciprocal characteristics of a 1500km HF Ionospheric Path," *Proceedings of the IEEE*, 55, March 1967, pp. 426-427; "Origin of non-reciprocity on high-frequency ionospheric paths," *Nature*, pp. 483-484, and cited references.
6. Davies, Kenneth (1990). *Ionospheric Radio*. IEE Electromagnetic Waves Series #31. London, UK: Peter Peregrinus Ltd/The Institution of Electrical Engineers. pp. 184–186. ISBN 0-86341-186-X.
7. George Jacobs and Theodore J. Cohen, *Shortwave Propagation Handbook*. Hicksville, New York: CQ Publishing (1982), pp. 130-135. ISBN 978-0-943016-00-9
8. Frank Kleijer (2004), Troposphere Modeling and Filtering for Precise GPS Leveling (http://www.ncg.knaw.nl/Publicaties/Geodesy/pdf/56Kleijer.pdf). Ph. D. thesis, Department of Mathematical Geodesy and Positioning, Delft University of Technology
9. WSPR Propagation Conditions Map: http://wsprnet.org/drupal/wsprnet/map
10. Network of CW Signal Decoders for Realtime Analysis: http://www.reversebeacon.net/

Further reading

- Lucien Boithais: *Radio Wave Propagation*. McGraw-Hill Book Company, New York. 1987. ISBN 0-07-006433-4
- Karl Rawer:*Wave Propagatiom im the Ionosphere*.Kluwer Acad.Publ.,Dordrecht 1993. ISBN 0-7923-0775-5
- H. Ward Silver and Mark J. Wilson, (eds), "Propagation of Radio Signals" (Ch. 19, by Emil Pocock), in *The ARRL Handbook for Radio Communications (88th edition, 2010), ARRL, Newington CT USA ISBN 0-87259-095-X*
- Yuri Blanarovich, VE3BMV, K3BU: "Electromagnetic Wave Propagation by Conduction" CQ Magazine June 1980, p. 44, http://k3bu.us/propagation.htm

External links

Wikimedia Commons has media related to ***Radio propagation***.

- Solar widget (http://rigreference.com/solar) Propagation widget based on NOAA data. Also available as WordPress plugin.
- ARRL Propagation Page (http://www.arrl.org/propagation-of-rf-signals) The American Radio Relay League page on radio propagation.
- HF Radio and Ionospheric Prediction Service - Australia (http://www.ips.gov.au/HF_Systems/)
- NASA Space Weather Action Center (http://sunearthday.nasa.gov/swac/data.php)
- HF Propagation Tutorial by the late NM7M (http://www.astrosurf.com/luxorion/qsl-hf-tutorial-nm7m.htm)
- Space Weather and Radio Propagation Resource Center (http://sunspotwatch.com) Live data and images of space weather and radio propagation.
- Solar Terrestrial Dispatch (http://www.spacew.com/)
- Online Propagation Tools, HF Solar Data, and HF Propagation Tutorials (http://www.hamqsl.com/solar.html)
- DXing.info - Propagation links (http://www.dxing.info/propagation)
- HF Radio Propagation Software for Firefox - Propfire (http://www.n0hr.com/Propfire.htm) Firefox plug-in for monitoring propagation, website utility to display HF propagation status, and article on understanding HF radio propagation forecasting
- The Basics of Radio Wave Propagation (http://ecjones.org/propag.html) A resource by Edwin C. Jones (AE4TM), MD, PhD, Department of Physics and Astronomy, University of Tennessee.
- Dynamic Radio Propagation Data (http://dx.qsl.net/propagation/propagation.html) Constantly updated radio propagation data pulled from various sources.
- Solar Cycle 24 prediction and MF/HF/6M radiowave propagation forecast webpage (www.solarcycle24.org) (http://www.solarcycle24.org/)
- 160 Meter (Medium Frequency) Radiowave Propagation Theory Notes webpage (www.wcflunatall.com/nz4o5.htm) (http://www.wcflunatall.com/nz4o5.htm/)
- Unusual HF Propagation Phenomena. 13 Apr 2009 (http://www.qslnet.de/member/la3za/prop/) Includes useful recordings each type. Retrieved 9 Oct 2009.
- Overview of radio propagation modes (http://www.radio-electronics.com/info/propagation/radio-propagation/radio-propagation-overview-tutorial.php)
- Propagation: Es & Thunderstorms (http://lists.contesting.com/archives//html/Propagation/2005-04/msg00075.html) by Thomas F. Giella, NZ4O, ex KN4LF.
- Radio propagation tutorial (https://www.electronics-notes.com/articles/antennas-propagation/propagation-overview/basics.php)

The following external references provide practical examples of radio propagation concepts as demonstrated using software built on the VOACAP model.

- Online MOF/LOF HF Propagation Prediction Tool (http://www.hamqsl.com/solar1.html#moflof)
- High Frequency radio propagation de-mystified. (http://hfradio.org/ace-hf/ace-hf-demystified.html)
- Is High Frequency radio propagation reciprocal? (http://hfradio.org/ace-hf/ace-hf-reciprocal.html)
- How does noise affect radio signals? (http://hfradio.org/ace-hf/ace-hf-noise.html)

The following external link is designed for use by cell phones and mobile devices that can display content using Wireless Markup Language and the Wireless Application Protocol:

- WAP/WML Space Weather and Radio Propagation Resources (http://wap.hfradio.org/) Space weather and radio propagation resources.

Categories: Radio frequency propagation

By Mark Kesauer, N7KKQ

An Inexpensive External GPS Antenna

If you operate APRS or just need an external antenna for your GPS receiver, here's one that is easy to build yet offers surprisingly good performance in a compact size. Best of all, it uses commonly available components and materials.

This antenna design is based on a classic turnstile configuration (for circular polarization)—two dipoles are placed on the same plane but rotated 90° from each other. These dipoles are then spaced ¼ wavelength above a ground plane. A ¼ wavelength "parallel-plate" transmission line (printed circuit-board material) serves as the connection method and mounting post for the dipoles.

Construction

Start with the base plate. Cut a 4-inch diameter circle out of thin hobby tin or brass. (It happens that the inside diameter of the container lid is 4 inches, approximately the same width as the hobby tin/brass sheet.) Mark the exact center of the base plate. This is where the parallel-plate transmission line assembly is attached (see Figure 1).

Cut two 4-inch lengths of #14 solid copper or brass wire and bend each in the exact center at 90°. Make the radius of the bend as small as possible. Set these aside, they will be soldered to the parallel-plate section later.

Select an 8-foot length of RG-58/U, RG-174 or RG-188 coax. Attach a male BNC connector to one end (or whatever compatible connector is used on your particular GPS receiver). I used a solderless connector but removed the screw and then soldered the center conductor directly into the screw hole. If your GPS unit has a BNC antenna connection, you can use an Ethernet coax cable found at most computer stores. Just make sure they are 50 Ω. They'll already have the BNC connectors crimped on each end. Just cut in the center, trim to length and you'll have enough for two antennas. The GPS frequency is 1.57542 GHz so the

Table 1
Materials

Hobby tin (K&S #254) or brass sheet (K&S #251) (0.010 thick).
Sheet of single-sided, glass-epoxy PCB material (FR-4 or G10 .062″ thick, enough to make two 2-inch pieces 0.250″ wide.
Solderless right-angle male BNC connector (RadioShack 278-126) or the appropriate type for your GPS receiver.
8-foot RG-58/U (Radio Shack 278-1314), RG-174 or RG-188 coax.
8-inch #14 solid bare copper or brass wire.
Empty 8-oz cream cheese container.
Misc—Clear 5-minute epoxy or superglue.
Clear spray lacquer, #600 fine sandpaper.

K&S Engineering, 6917 W 59 St, Chicago, IL 60638; voice 773-586-8503; fax 773-586-8556; **www.ksmetals.com/**.
RadioShack, **www.radioshack.com/**.

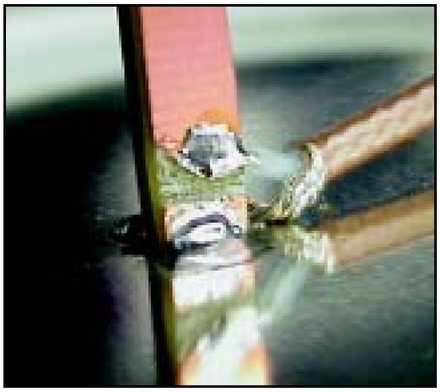


Figure 1—Close-up view of the coax connection to PCB transmission line and support.

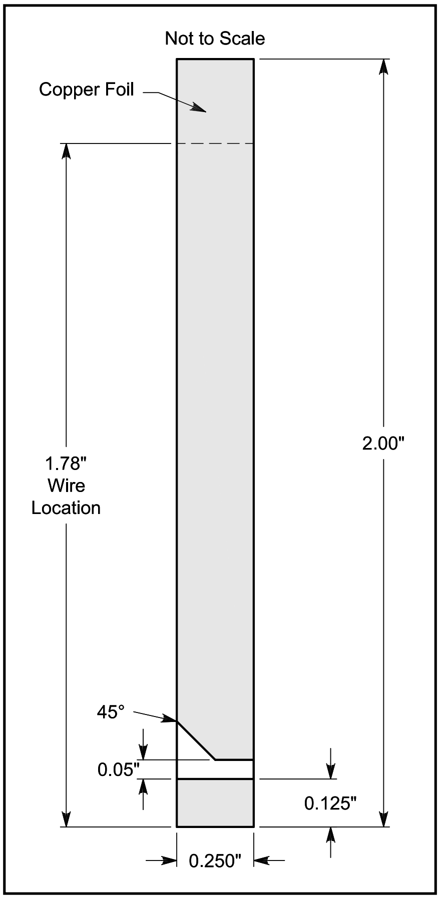


Figure 2—The active side of the transmission line.

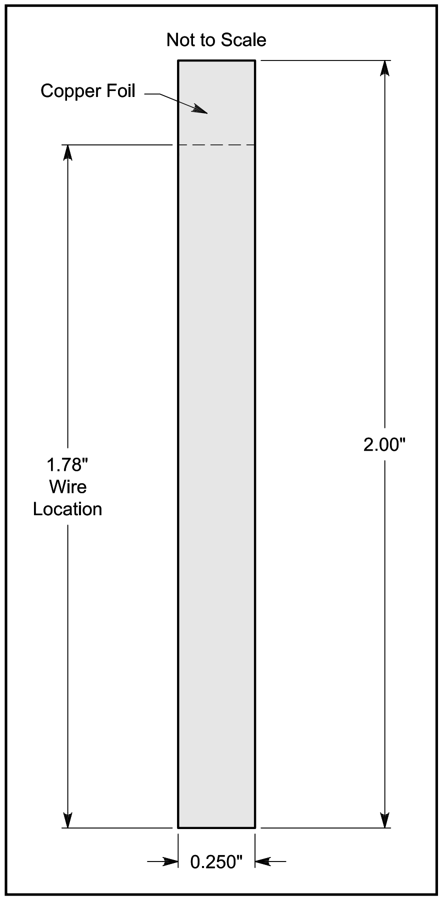


Figure 3—The ground side of the transmission line.

longer the coax, the greater the loss. Use no more than 8 feet—less if you don't need the length.

To make the parallel-plate transmission line, cut two 2-inch lengths of single-sided printed circuit board material that are 0.250-inch wide. Make sure it is glass-epoxy (FR-4 or G10 type material) and that it is 0.062-inch ($^1/_{16}$ inch) thick.

On one of the PCB strips, cut the copper foil with a sharp hobby knife or Dremel tool, as shown in Figure 1. This will be the "active" section of the parallel-plate where the other non-modified strip will be the "ground" side, as shown in Figure 2. The 45° cut on the active side is known as a "microwave turn" which allows the signal to effectively turn 90° to the coax. Glue the two strips together (copper outside) and set aside to dry.

I've found it easier to cut the PCB strips a bit wide and glue them together first. Then I just file both edges to the correct dimensions. A light sanding with #600 sandpaper finishes off the edges and removes any burrs.

Double-sided 0.125-inch thick PCB material could be used but can be difficult to obtain for the average hobbyist. Conversely, by using a single 0.063-inch thick double-sided material we would be working with a rather small and fragile structure (half the thickness equates to roughly half the width). This might not hold up during handling and operation. By using the two sections glued together, we've solved the problem by creating our own 0.125-inch thick material.

Solder the transmission line section to the base plate keeping it as square and plumb as possible. Drill or melt a hole in the plastic container the same diameter as the coax. Feed the end of the coax through the hole and attach the coax to the transmission line active side as shown in Figure 4.

Measure 1.78 inches up from the base end of the parallel-plate section and scribe a line in the copper foil. Solder one of the #14 wires to the ground side of the parallel-plate section. Position as shown in Figure 4. Do the same with the active side—you may need a helping third hand as it's difficult to hold the soldering iron, antenna and position the wires all at the same time.

Measure each leg of the horizontal wires and trim to 1.51 inches from the center junctions. Next, trim both the 45° wires to 1.82 inches from the center junction. If all went well, you should have approximately ½ inch between the tips of the 45° wires and the base. If not, carefully resolder or bend the wires to this dimension.

Using a fine saw or a Dremel tool, remove the excess length of the transmission line just above the wire junctions. Sand the exposed junction to remove any burrs and check for a short circuit.

Note that we've purposely kept the transmission line section length long, until after construction. The thin copper foil tends to separate from the glass epoxy during heavy duty soldering. The longer length acts as a heatsink to preserve the bond between the copper foil and the glass-epoxy base.

Final Assembly

I've found that an empty, upturned 8-ounce cream cheese container makes a practical radome for the antenna. More importantly, it helps protect the internal workings from mechanical damage.

I usually don't paint the container but I do remove the silk-screened label by using an automotive rubbing compound. It takes some effort but it does come off. Just follow the manufacturer's instructions. Be careful not to apply too much pressure to the lid when you rub the label off. It's made of a different plastic than the container and stretches easily.

You should be able to snap the base plate into the lid of the container. It's a tight fit so just work your way around the lid until the entire base plate is flush with the lid bottom You might have to cut a notch in the lip of the lid to allow the coax to exit the unit cleanly. Carefully align the coax with the lid notch and snap the cover onto the lid. It's normal for the top of the transmission line assembly to slightly raise the "bump" on the container bottom.

Theory of Operation

In a normal turnstile, we would have a double dipole configuration with both dipoles on the same plane but rotated 90° from each other. Additionally, the second dipole is fed 90° out of phase with an-

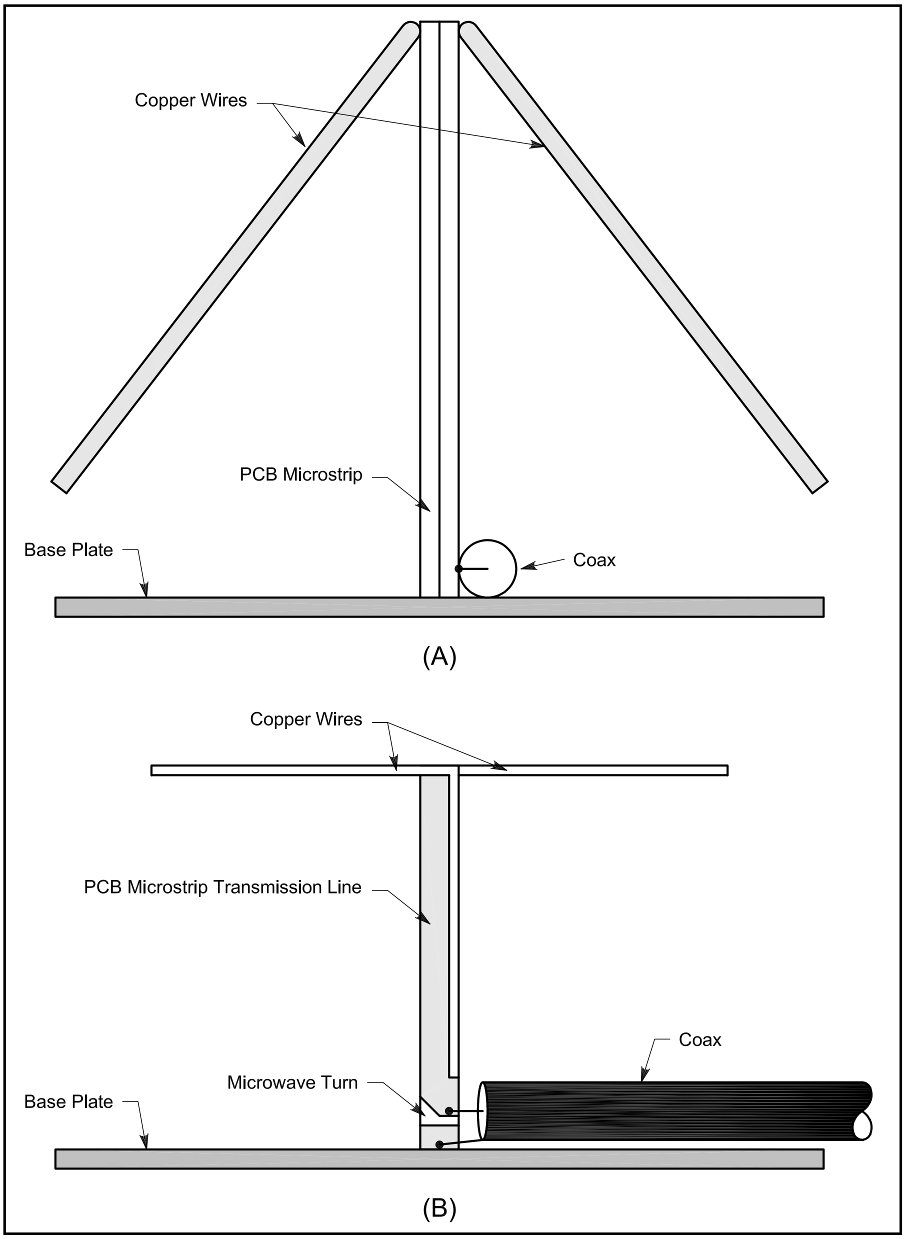


Figure 4—Side (A) and front (B) views of the parallel-plate transmission line and radiating elements.

other ¼ wavelength of coaxial cable (see Notes 2 and 3). This creates some difficult assembly problems since you would have to isolate the second dipole section from ground while maintaining the tight distance and spacing requirements. Due to the size constraints, this second dipole connection would require a very small diameter coax that might be difficult to work with and even harder to obtain. With this antenna, we cheat a bit and use a self-phased quadrature type feed.

To obtain circular polarization without a coaxial phasing line, the shorter dipole is cut so its impedance is $50 - j50\ \Omega$. The longer dipole is fashioned into an inverted V shape and cut so its impedance is lowered to $50 + j50\ \Omega$. With the combined asymmetrical dipoles and with them spaced slightly closer than ¼ wavelength to the ground plane, the antenna's impedance is near 50 Ω with a much more omnidirectional pattern, an important consideration for reception of GPS satellites close to the horizon.

Operation

Connect the antenna to the GPS receiver and watch the signal-strength indicator. You should see an improvement over the supplied stock antenna. You can tweak the antenna by bending the wires up and down gently and watching the results on your GPS unit. Be careful of the solder joint—it's rather fragile. Adjust for maximum displayed signal. Repositioning the antenna may also improve reception. With this antenna, I routinely receive five to eight satellites on my Garmin II receiver.

If you are using a GPS unit that sends dc voltage volts up the coax to power an external preamp or amplified antenna, don't worry. Since the elements are not grounded or shorted, there is no dc path. Just be careful not to let either end of the active elements touch ground. [Be ad-

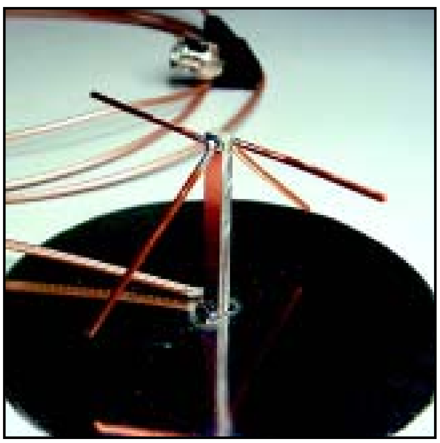


Figure 5—View of the parallel-plate support with elements attached.

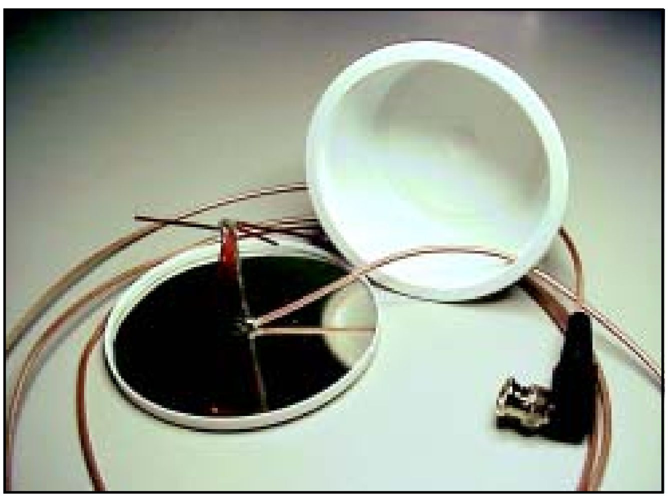


Figure 6—The finished GPS antenna with radome ready to snap into place.

vised that some GPS receivers with internal patch antennas have an antenna switching circuit. This circuit disables the internal antenna when an amplified external antenna is attached. The receiver senses current flow that is intended to power the amplifier of the external antenna. If your receiver has this feature, you will want the switch to activate and disable the internal patch antenna. Placing 1 kΩ to 5 kΩ across the ground and center conductor of the coax should be sufficient. Check with the manufacturer of your GPS receiver.—*Ed*.]

If you are mobile, most GPS receivers will do a fair job of receiving signals through the windshield of a car. During the summer, however (and especially out here in the Southwest), the GPS gets baked while sitting in the hot sun. Obviously, one way to solve this problem is to locate the receiver somewhere cooler and place this external antenna on the dash. Once that's done, you've protected your expensive receiver while sacrificing a $10 antenna.

This design was not intended for outside use, hence the lack of external mounting suggestions. Any prolonged exposure to the elements will degrade the antenna's unprotected metal parts. My suggestion—if you plan on using this unit outside, at least spray the metal parts with clear lacquer and seal the exposed coax end with RTV. Otherwise, don't waste a lot of time weatherproofing it. Because these antennas are so cheap and easy to build, if one does deteriorate throw it away and build another. Perhaps you might want to keep a couple of spares on hand, just in case.

My thanks to Zack Lau, W1VT, of the ARRL Lab for his advice and expertise.

Notes

[1]Tom Hill, WA3RMX, "A Triband Microwave Dish Feed," *QST*, Aug 1990.

[2]Zack Lau, W1VT, "A Simple 10-Meter Satellite Turnstile Antenna (RF)," *QEX*, Nov 2001.

[3]Zack Lau, W1VT,"A Simple 10-Meter Satellite Turnstile Antenna (Feedback)," *QEX*, Jan 2002.

Mark Kesauer, N7KKQ, received his Novice license in 1969. He has held the call signs WN8CGM, KA5ZCH and his present Extra class call sign. Mark belongs to QCWA, Ten-Ten International and has been a longtime ARRL Member. Mark holds an Engineering degree and has been a Computer Aided Designer (printed-circuit boards) for 29 years. Mark may be contacted at **n7kkq@arrl.net**.

FEEDBACK

◊ The impressive 13-star flag flying proudly from page 20 of Sep 2002 *QST* is actually a Bennington Flag, not a Ben Franklin flag. Our thanks to several readers who pointed out that the original can be seen at Vermont's Bennington Museum (**www.benningtonmuseum.com/flaghistory.html**).

◊ In the Apr 2002 *QST* article "AMRAD Low Frequency Upconverter," there is a short across R10 in Figure 2. That short should be removed. Also, early versions of the PC board used a slightly different crystal oscillator circuit. That circuit worked fine except it occasionally would not start. Several of those boards were shipped from FAR circuits. If you have one, they will exchange it for the later circuit if you wish. The older circuit is shown in the hand-drawn schematic on the AMRAD LF Web page at **www.amrad.org/projects/lf/** if you wish to use the older circuit.

STRAYS

VIDEOCONFERENCING BOOK FROM K8OCL

◊ John Champa, K8OCL, has written a new book titled *Videoconferencing Skills*. The book offers students and instructor's detailed information about how to present dynamic and forceful videoconference meetings. The ten lessons in *Videoconferencing Skills* provide an activity-driven approach with three to five activities in each lesson, instructional illustrations, an introduction to the equipment used in videoconferencing, instruction in preparing PowerPoint slides for a videoconference and much more. A separate instructor's manual is available as well. John has been a ham since 1959 and is chairman of the ARRL High-Speed Digital and Multimedia Working Group. *Videoconferencing Skills* is available for $11.50 (the Instructor's Manual is $15) from: Thomson Learning, Order Fulfillment, 10650 Toebben Dr, Independence, KY 41051; tel 800-354-9706 (8 AM-6 PM Eastern); **www.swlearning.com**.

NEW PRODUCTS

THE K2/100 HIGH-PERFORMANCE HF TRANSCEIVER KIT FROM ELECRAFT

◊ Elecraft's landmark K2 kit transceiver is now available in a 100-W model. The compact K2/100 is based on the K2, with the same features and same world-class receiver performance. It has the portability and efficiency of a QRP transceiver with a 100-W punch when you really need it.

Created by Elecraft co-founders Wayne Burdick, N6KR, and Eric Swartz, WA6HHQ, the K2/100 uses an integral heat sink as its top cover, thus retaining the same form factor as the base K2.

Features include silent, diode-based T/R switching; a built-in remote control port with true RS-232 levels; low receive-mode current drain for enhanced portability; all basic K2 features, including dual VFOs, multiple memories, split TX/RX operation, RIT/XIT, full-break-in CW, built-in memory keyer, narrow IF crystal filtering, excellent receiver dynamic range and IF-derived AGC.

The K2/100 shares a number of K2 options, including the KSB2 SSB adapter, KNB2 noise blanker, K160RX 160-meter adapter with second receive antenna jack, KAF2 audio filter/real-time clock and the MH2 Heil/Elecraft microphone.

Price: The K2 sells for $589 and the KPA100 100-W Integration Kit (internal), which completes the K2 as a K2/100, sells for $349. For more information, point your Web browser to **www.elecraft.com** or e-mail **sales@elecraft.com**.

NEW 50-Ω COAX FROM CABLE X-PERTS

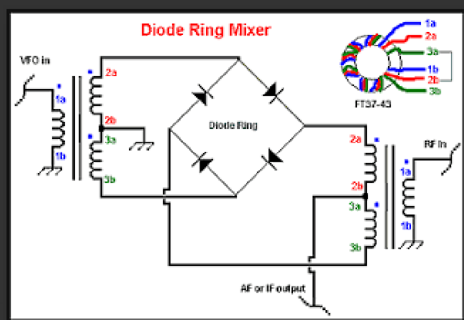
◊ Cable X-Perts, Inc, is pleased to introduce a new version of their CXP1318FX, a 50-Ω low-loss coaxial cable. Manufactured with a "gas-injected" foam polyethylene dielectric and a 19-strand center conductor, this cable is designed to give exceptional flexibility and reliability. Other enhancements include a double shield (100% bonded-foil and 95% tinned copper braid) and noncontaminating and direct-burial jacket. Nominal attenuation (per 100 feet) is said to be: at 150 MHz, 1.6 dB; 450 MHz, 2.9 dB; 1200 MHz, 5.0 dB, and 2400 MHz, 7.5 dB. Available in bulk and ready-made lengths with UHF (PL-259) and N connectors. For more information, see **www.cablexperts.com** or via email at **cxp@cablexperts.com**. Cable X-Perts, Inc, 225 Larkin Dr, Ste 6, Wheeling, IL 60090-7209, tel 800-828-3340; Fax 847-520-3444.

du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

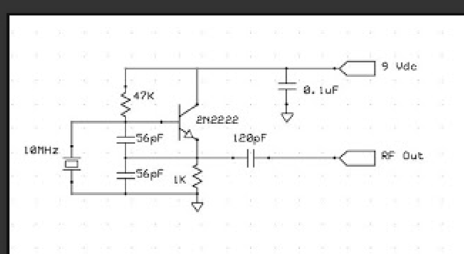
Monday, August 28, 2017

Diode Ring Mixer



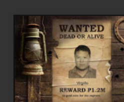
40m band is poor today and I am wanting to listen to AM broadcast band but my IC-M700TY hf transceiver can only go 2MHz. Checking my junk box I found the right components to assemble an up converter so that AM broadcast can still be heard in my transceiver.

The illustration above is a diode ring mixer, In my prototype, I am using four 1N4148 diodes closely matched by their forward voltage and a pair of FT37-43 toroid as a core for my broadband transformer where four trifilar turns of #22 awg insulated wire is wound.



After completing the diode ring mixer, I made the 10MHz crystal oscillator following the circuit above. I am getting 2.8V peak to peak of 10MHz signal from the oscillator and I think this so much for a ring mixer requirement. The 10MHz signal will go in the VFO port of the ring mixer.

About Me



hevirred

Ham since 2000.

View my complete profile

My completed prototype is incased in a plastic container and pair of connectors is mounted on the side to accommodate quick connection of the aerial antenna and the patch cable leading to my IC-M700TY antenna connector. The aerial antenna will go in the RF port while the baseband output signal is extracted at the IF port of the ring mixer.

Now for this to work, the AM broadcast frequencies will be present at (10MHz + AM band) and at (10MHz - AM band). DZMM is broadcasting at 630KHz and this can be heard either at 10.630MHz or at 9.370MHz ---73 de du1vss

Posted by hevirred at 12:27 AM

No comments:

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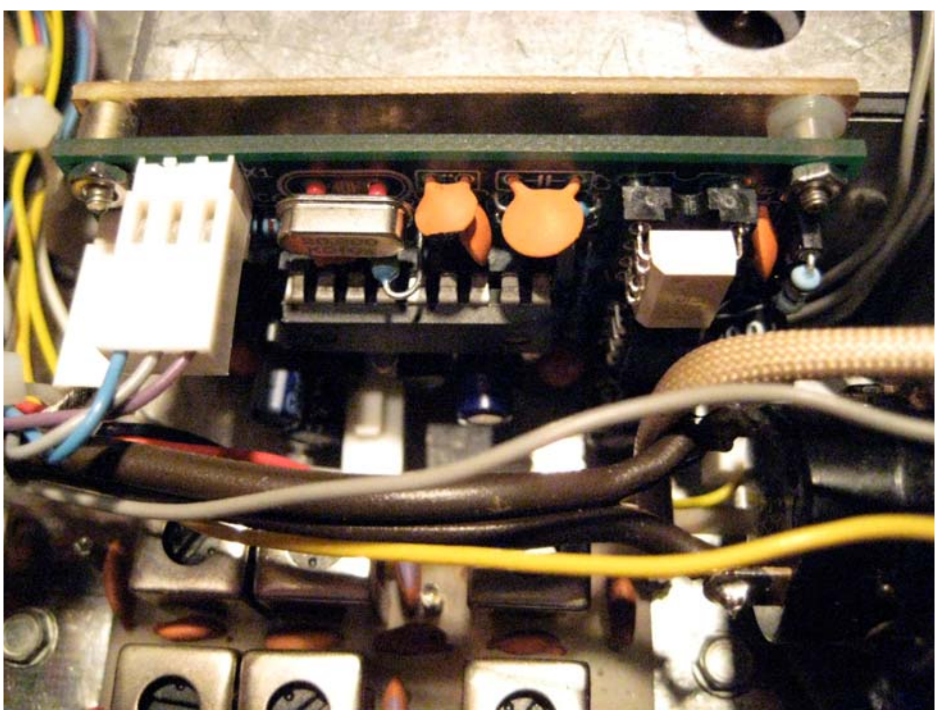
Adding the Cumbria Designs X-Lock 2 to the Ten Tec Corsair I

Pete Juliano, N6QW radioguy90@hotmail.com

Early in 2011, I couldn't resist purchasing a Ten Tec Corsair I. The unit was in medium condition to which I added the optional 500 Hz CW Filter. The radio performs very nicely save for one annoying problem – it drifts. But it does have an unusual drift characteristic. From a cold start it will drift upward about 500 Hz over a two-hour period and then it would settle down and stay put. Such a long warm up period obviously was a problem especially if you turned on the radio and just wanted to make a few short contacts. The other option was to keep the radio on at all times. After a few weeks of this problem I looked for some way to stabilize the PTO.

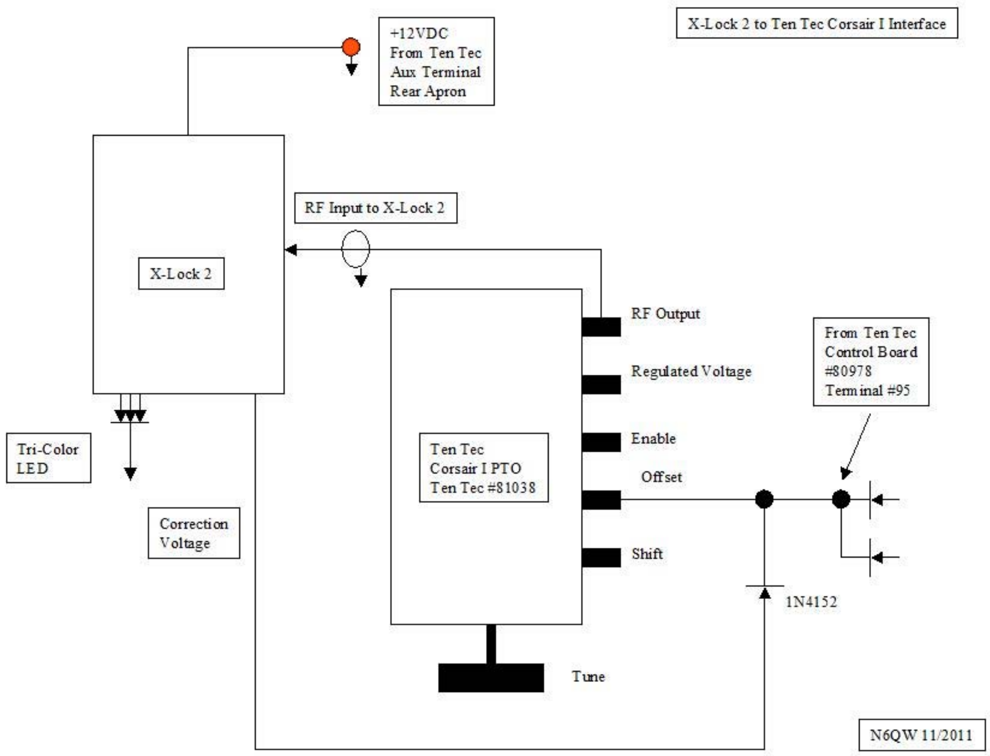
I am no stranger to huff and puff circuits, in fact I have built about a dozen or so especially the one shown on EI9GQ's website, (Ed Skelton). But that circuit employed it's own display and I wanted to use the factory display. I next looked to purchasing a commercial unit from Ron Taylor, G4GXO known as the X-Lock 2. After reading some of the user inputs on Ron Taylor's website (Cumbria Designs) I was convinced this was the solution. It was indeed.

The X-Lock 2 is a high quality kit and I can't say enough about the instruction manual. It is simply superb! Ron Taylor has created a very nice kit that is a solution to the older non-DDS type Variable Frequency Oscillators. As luck would have it there is a small space right next to the Ten Tec Corsair I PTO and it tucks into that space very nicely. So connections to the Corsair are easily accomplished. See Below.

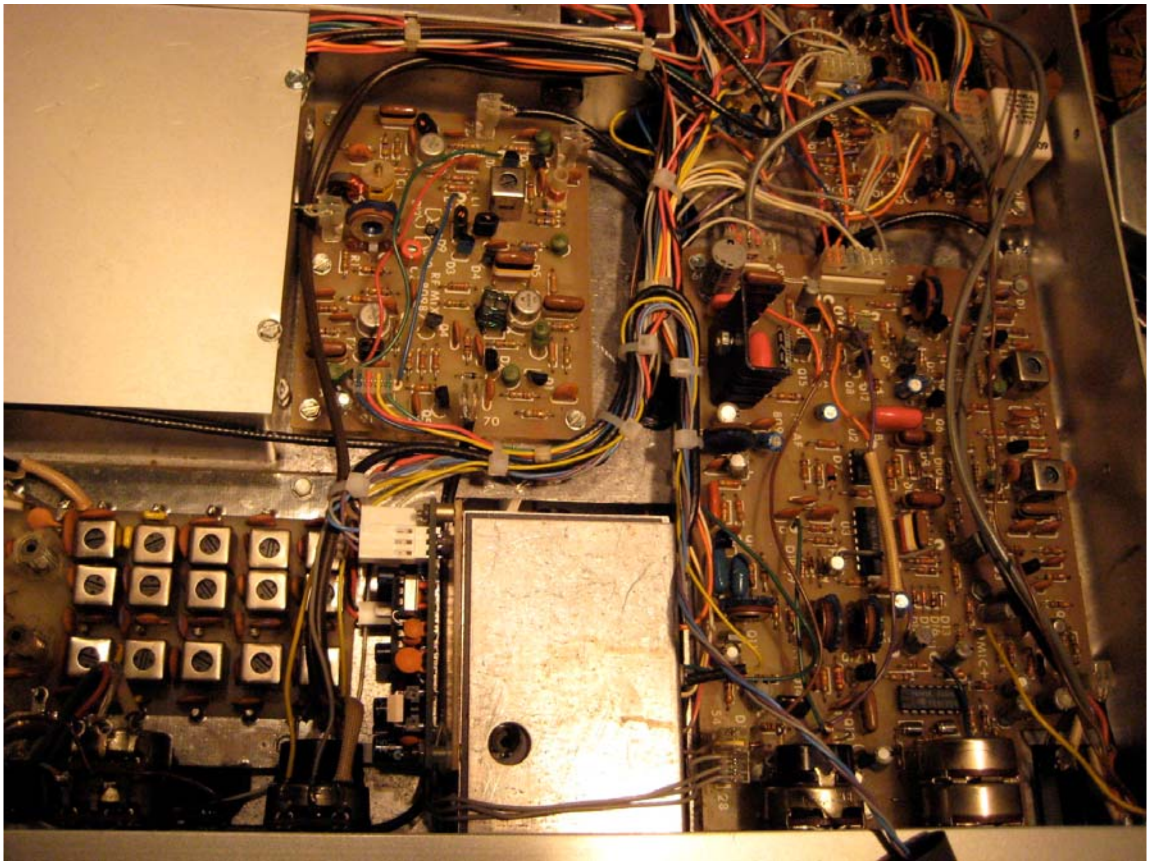


A couple of build notes:

1) I used four small glass beads that are used in beaded jewelry making to elevate the crystal from the circuit board. Two beads are stacked and slipped over the leads of the crystal to elevate the crystal above the board so it will not be damaged by heat during the soldering process. Taylor recommends two millimeters (mm) above the circuit board. Yes you guessed it –two beads stacked on top of each other, were two mm high. The inside diameter of the beads is a really good fit for the wire crystal leads. See the red beads on the photo above.
2) For the tri-color LED I solder a plug on the end to match the header on the PC Board. This arrangement facilitates the initial testing so the LED and circuit board are a singular assembly. I then made up an extension cable so the LED then can plug into that cable, which is now plugged into the circuit board and routed outside the radio through one of the bottom access holes. Since the wiring to the LED at the extension socket is exposed I put a piece of heat shrink tubing over the end to cover the exposed wire. But I did not shrink the tubing. Instead I simply taped the assembly to the bottom of the radio case and the LED sticks out just a bit from the bottom of the front panel. No holes and all can be easily removed.
3) Interface to the Corsair I takes one signal diode, a 1N4152 connected to the X-Lock output on the Anode side and to the Offset terminal on the Cathode side. The PTO on the Corsair I has the following 5 terminals along the housing side: 1) RF Out, 2) Regulated Voltage In, 3) Enable (connected to the back connector and supplies a regulated voltage), 4) Offset and 5) Shift. In the case of Offset and Shift, these terminals have the following connections inside the PTO: 10NF to ground, a 100K resistor connected to a varicap Finally to either a 10PF (Offset) connected to the PTO tank circuit or an 18PF (Shift) connected to the PTO tank. The Offset is the port that will be used with the X-Lock. The source voltage from the Offset control located on the Control Board is already isolated with 1N4148 diodes. So there should be no worry about back feeding voltage in to the Offset circuitry. The 1N4152 mentioned earlier serves the same purpose so that the Offset voltage is not fed into the X-Lock. See the diagram below.
4) A piece of double-sided copper PC Board was cut to the same size as the X-Lock Board and holes were drilled in each corner that match the mounting holes in the X-Lock 2 Board. The copper PC Board was fitted to the X-Lock board using 3/16-inch plastic spacers and 2-56 nuts and bolts. The PC board prevents anything for shorting to the underside of the X-Lock 2 Board and serves another purpose. The bottom side of the copper PC board was fitted with a piece of double back tape and the assembly was moved into position near the left side of the PTO box (bottom side up and the panel facing you). The assembly was simply "glued" to the PTO using the double back tape. It is a convenient and protected location for the X-Lock board.
5) Cable ties were used to collect and route the X-Lock wiring to the various connection points on the bottom side of the Corsair chassis.
6) The Normal Offset Min and Max Ranges have been somewhat reduced a result of the steady state correction voltage being supplied by the X-Lock 2 but this is considered a small nit given the dramatic improvement in frequency stability.



See below for how the X-Lock 2 was fully integrated into the underside chassis of the Corsair I. Power is supplied simply by tapping into the Auxiliary 12 Volt DC connector on the back apron. The other two connections are to sample the RF output of the PTO (using a short length of RG-174-U Coax) and the correction voltage applied through a IN4152 right at the Offset terminal of the PTO. A piece of the insulated jacket from the RG-174-U was slipped on the wire going to the Offset terminal and when the wire/1N4152 were installed the jacket was slipped over the connection to prevent any shorts. Thus five total connections are required; 2 for the power, 2 for the Coax and 1 for the correction voltage. All can be undone in a matter of minutes. The Tri-Color LED is simply taped to the bottom of the Corsair Case, after placing a piece of heat shrink tubing over the exposed connections. On December 2, 2011 I ran an interesting test. I simply turned on the Corsair I, and noted the frequency. Three hours later is was on the same frequency. I call that pretty amazing for a radio using a PTO and is perhaps nearing its 30th Birthday.



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KD1JV Tri-Bander CW transceiver

Specifications

- Any three ham bands, 80, 40, 30, 20, 17 or 15 meters, choose at time of order.
- 5 watts output on all bands with 13.8V supply
- Built in Iambic keyer with 5 to 40 wpm code speed, selectable Iambic A or B modes and two 63 character message memories.
- Receiver sensitivity, 0.2 uV MSD
- DDS VFO for rock steady stability with 50 Hz and 200 Hz tuning rates
- Easy to read four digit LED display with leading zero suppression.
- Rotary knob tuning
- RIT (receive incremental tuning)
- Four IF crystals for excellent selectivity and opposite side band rejection
- 600 Hz audio filter
- Audio derived AGC
- Small size, 6" wide, 1.5" tall and 4" deep.
- Light weight, 12 ounces.
- Modest supply current requirements, 90 ma on receive (no signal) and 600 to 800 ma on transmit at 5W out (current depends on band, higher bands draw more current)

Manuals and other useful information

KD1JV Tri-Bander Construction Manual (7-26-2016)

Tri-Bander Revision A.1 Addendum

Revised Assembly instructions for the Bail

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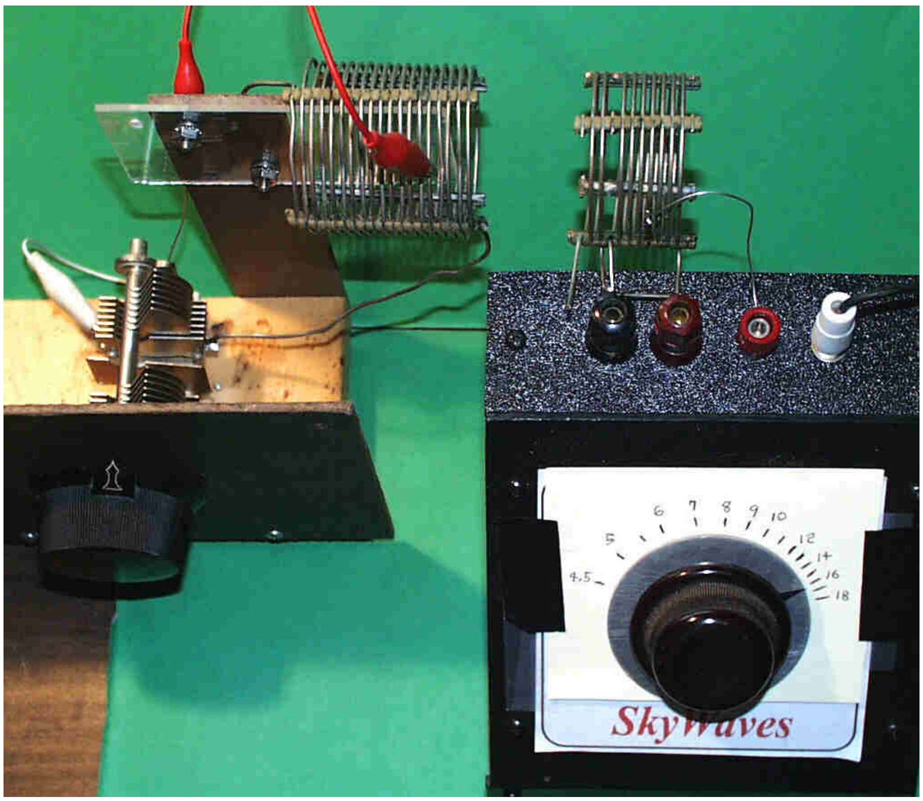
The SkyWaves Short-wave Crystal-set Prototype

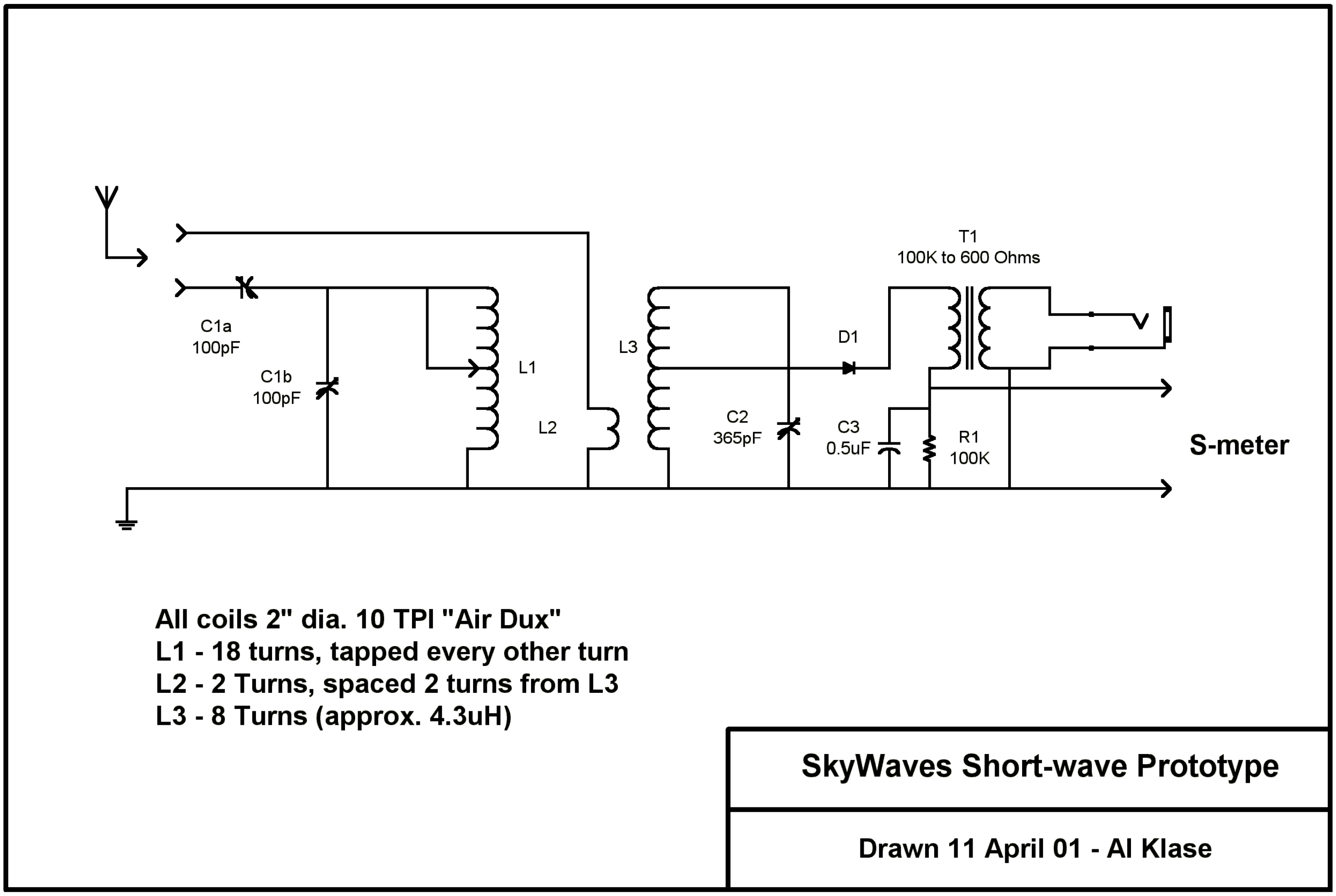
Here's some info on my recent short-wave crystal-set experiments. The basic conclusion is that SW crystal sets are quite worthwhile, and need not be unduly elaborate to give gratifying results. This is especially true on the US east coast where the "prime time" broadcasts are really strong.

A word of warning: You're likely to hear strong, clear English broadcasts from the likes of The BBC, The Voice of Viet Nam, and Radio Taipei. Don't believe it! These are rebroadcast from nearby sites in US and Canada. To sort this out, there is a good frequency list available at: http://www.primetimeshortwave.com/

I the short time I've been at it, I have heard Radio Exterior de Espana , Swiss Radio International, and The Voice of Russia from my West-central NJ location. So intercontinental DX is entirely possible. I even heard a "numbers station" on about 13.5MHz.



This is a simple double-tuned radio built around Air Dux coil stock. I used this because it was handy, but solid bare wire of about 14 gauge on 2" PVC should work just fine. (Strip a length of #14 Romex.) The primary tuned circuit is Tuggle style and offers a reasonable compromise between effective, flexible antenna matching and ease of use. I bent down every other turn on L1 to make it easy to tap with an alligator clip. I equipped the secondary coil with a separate "primary" winding so the set can be used in the single-tuned mode to do a quick band scan. Coupling is controlled by moving the two sections around on the table. The "ground" end of the coils face each other.



Some additional observations: A secondary coil of about 4 – 4.5 uH will tune 5-18 MHz with a 365pF cap. That's where 95% of the action is, so band switching can be avoided. As with most double tuned sets, a calibrated dial on the lightly-coupled secondary really helps sort things out on the air. I'm using sound-powered phones, but signals are strong, so a modest headset will be ok for starters. Just elininate T1, C3, and R1, and connect the headset between the diode and ground.

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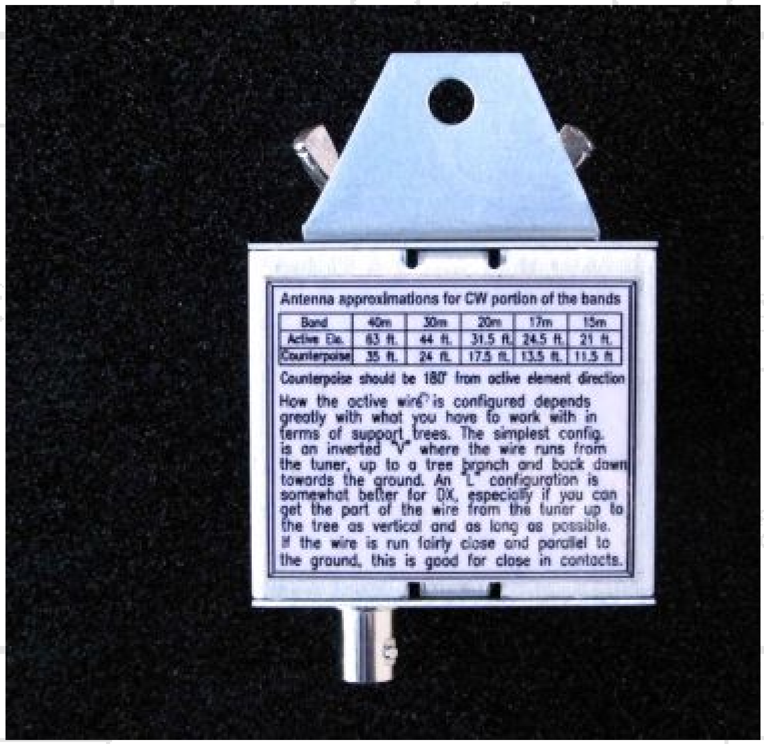
40m - 15m or 80M SOTA Halfwave Tuner



The SOTA tuner can be either built for 40-15 or 80. The product we developed is enclosed in a sturdy aluminum case, and features Dan Tayloe's (N7VE) led swr indicator, with all stainless steel connection hardware. We are rating the tuner at 5 watts CW, 10 watts P.E.P. The light weight and small size make this tuner ideal for the backpacker and because it is so small, you won't even notice it in your luggage as you travel. This tuner is perfect for the people who like to take a small rig with them when they travel on business for hotel operation. Plus, the Tayloe SWR indicator eliminates the need for additional SWR bridge, and associated cables. All that you have to do is attach the tuner to a wire, hook it to your rig, and then tune until the LED dims or goes out. When that happens you are ready to operate. It doesn't get any simpler. The SOTA tuner is perfect for the backpacker and traveler. It is small in size, simple to operate, and easy to build.

The finished tuner is just 2"x 2 1/4"x 7/8", and the weight is 2.54 oz., or (72 grams) !!

Supporting Files and Documents

[SOTA Assembly Manual 40M - 15M (5/30/2017)]

[SOTA Assembly Manual for 80m (5/30/2017)]

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SOTA Tuner (40m-15m): $40.00 Add

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MORSECODE IS GOING TO CHANGE!

(2005)

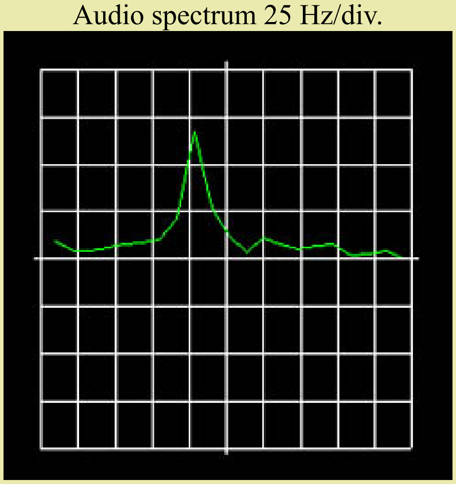
KLIK HIER VOOR DE NEDERLANDSE VERSIE

Drastic change of Morsecode!
Indeed it is the most drastic change but also a big improvement since the invention of the code. The long DASH will be replaced by a DOT with a tone shift. The tone-height is 50 Hz higher than the normal DOT.

The problem
The problem is that correct decoding of Morsecode can only be done by ear. As the employees in Monitorstations that can do that will retire soon, it is necessary to change the transmit mode so that it will be possible for the Authorities to decode CW signals correctly with use of PC's. In principle, the Morsecode is not changed but only the way the code is transmitted. But the new mode has so many advantages that it should be implemented as soon as possible!

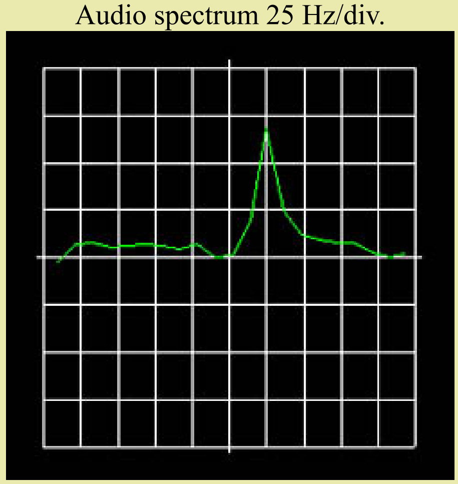
The solution, from DOT-DASH to TWOOT-TWEET!
In fact it is already an existing Morsecode mode, invented by Radio amateurs! This mode is used for CW transmissions of QRPp beacon transmitters and is called Dual Frequency CW or DFCW. These beacons use a shift of 5 Hz but that is too small for decoding by ear. Therefore, the DASH is replaced by a DOT of which the tone is 50 Hz higher instead of 5 Hz.

Audio spectrum 25 Hz/div.



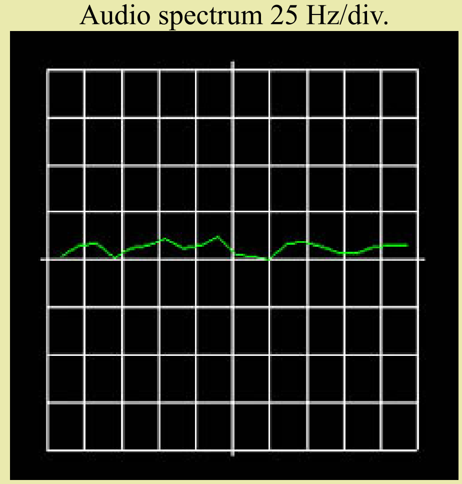
A 700 Hz tone: a DOT!

Audio spectrum 25 Hz/div.



A 750 Hz tone: a DASH!

Audio spectrum 25 Hz/div.



No specific tone: a space

An example
Let's take the character A (**.-**) as an example at 12 wpm:

New Mode	**Old Mode**
100 milliseconds 700 Hz tone (DOT) 100 milliseconds off (space) 100 milliseconds 750 Hz tone (instead of a DASH of 300 milliseconds)	100 milliseconds 700 Hz tone (DOT) 100 milliseconds off (space) 300 milliseconds 700 Hz tone (DASH of 300 milliseconds)
300 ms total time 200 ms transmitter on time	500 ms total time 400 ms transmitter on time

The new transmit mode for the Morsecode can be decoded quite easily by computer software. Not the length of the signal but the frequency is the factor that is important. Decoding is simple and clear: When a DOT is transmitted, then the 700 Hz audio channel is the strongest one. When a DASH (now a DOT with 50 Hz tone shift) is transmitted, the 750 Hz audio channel is the highest level. Are both channels more or less the same, then it is a space or interference. As all the symbols have the same length, it is much easier to decode the end of a character and if it is a DOT or a DASH.

Nowadays we do have everywhere telephone and internet and it is hard to find people that can decode Morsecode!

Advantages!

- In contrast with other digital mode's, this is the only one that can be decoded not only with a PC but also by ear! Also sending the code can be done as well as with a computer as manually with a paddle key! Everyone can use this new Morsecode, Old Timers with a key and decoding it by ear but also the young amateurs with PC's and modern software. It is an ideal communication mode between these two groups of radio amateurs!
- For QRPers it has the advantage that 50% of the transmitter energy is saved because the long DASH is replaced by the short DOT with a tone shift. The battery life of the simple QRP transmitters will double!
- For QROers, the advantage is that the duty cycle (transmitter on / transmitter off ratio) will go from 50% to 30%. The temperature of the big tubes in the power amplifiers will become less hot and live much longer.
- The advantage for the High Speed CWers and the contesters is that the CW speed is increased by 20% because the long DASH is replaced by the short DOT with a tone shift. If they had used this mode in the Old Days, then the Marconist should have saved 20% or 1.6 hour per day on his working hours!
- This mode does not require a very high frequency stability as is the case with many digital modes.

Disadvantages
Of course there are some disadvantages too. The transceivers have to be modified. But simple modification kits will be available soon. For home made equipment only a few extra components are required like a varicap for the frequency shift.
It is not possible to use an ordinary CW key. You have to use a paddle, but in practice, everyone is already using that.

Finally...
The good old Morsecode will not disappear! The story was intended to be a joke but became so realistic that it was too difficult to distinguish it from reality! So it is nice to try DFCW with use of the DOS program that also works in Windows 95 and 98. Who knows, perhaps it will be an often used mode in the future!

The DFCW software:

Download the 05DFCW.ZIP (90k) file containing all the files including the source code. Unzip all the files in one directory and run (click) the executable (EXE) file. The NL version is in the Dutch language.

BACK TO INDEX PA2OHH

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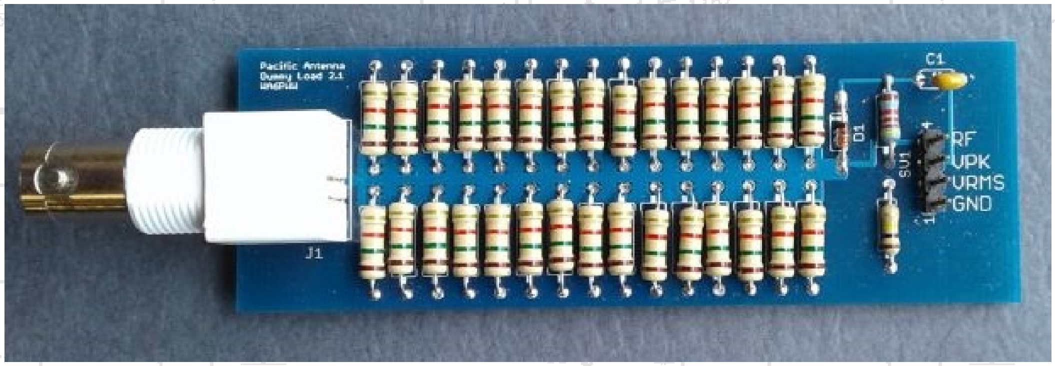
Dummy Load V2



Features

- Compact design using through hole parts
- Assembled with common soldering tools and techniques
- A great first time kit to learn or develop soldering skills
- Provides direct RF voltage, Peak and RMS values of the RF voltage.
- Measures RF Power from 0.1 to 15 Watts using an inexpensive digital Multimeter
- Covers DC to 50MHz

Supporting Files and Documents

Dummy Load Builders Manual V2 (09/20/2017)

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Tribander RevA.1 Addendum

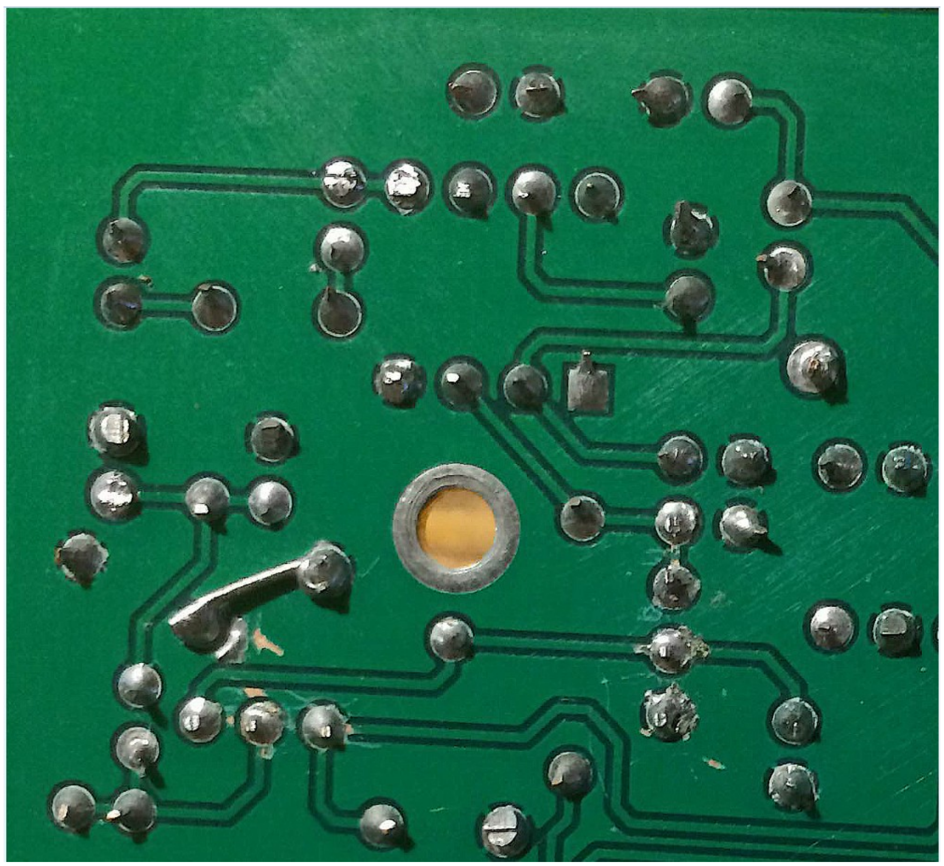
On our Tribander kits with a RevA.1 circuit board, there is a small modification that is needed in order for the audio chain to work correctly.

One pad of R18 located in the lower left quadrant of the board just adjacent to Q9 was left ungrounded and needs to be connected to ground.   This pad also has a trace right next to it but is not connected to the trace.

This the leftmost pad of R18as you look at the board from the top with the front side toward you.

Our recommended way to accomplish this is to add a wire between the unconnected pad of R18 and the adjacent, grounded pad of R25 as shown in the photo below. As these pads are grounded anyway, the wire does not need to be insulated from the surrounding groundplane.

The easiest way is just use the excess lead from either R18 or R25 and bend it over to reach the other pad. The photo below shows the location of the wire.

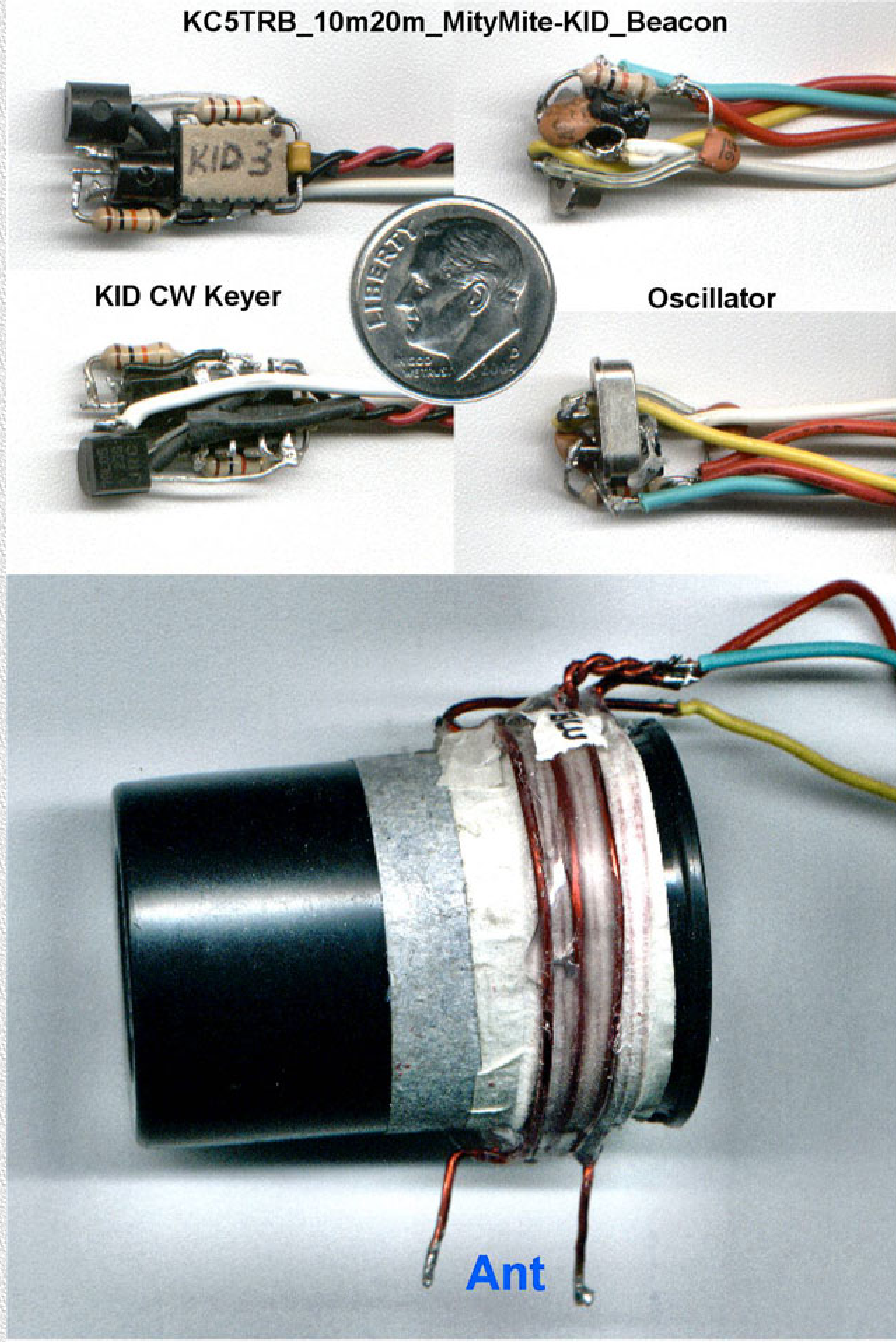


Please contact us if we can help clarify how to implement this.

Please Note that this only applies to the boards labeled: RevA.1, not previous versions.

Harry's Mini Mite

Harry sent me these pictures of his Miniture Mighty Mite for 20 meters. It is very interesting for those who want to always make things smaller. He has packed the whole 20 meter Mighty Mite into a 35 mm film plastic bottle. He used the outside of the film bottle as the coil form and put the rest of the electronics inside. He has had some success (a QSL card from 1200 miles away). So, it is being heard. The pictures he sent me below shows how he did it. He had also included a beacon keyer into the circuit. Very interesting Harry!!!


KC5TRB_10m20m_MityMite-KID_Beacon
KID3
LIBERTY
KID CW Keyer
Oscillator
Ant

Return to Mighty Mite Page

A Cost Effective Current-mode 1:1 Balun

Ralph Holland describes a 1:1 balun.

Introduction

A cost effective current-mode 1:1 balun can be constructed from a length of coax and a rod typically used for a broadcast antenna loop-stick, some electrical tape, cable ties, a length of PVC water-pipe and some connectors. The balun is formed by winding several turns of coax on the ferrite rod.

Principle

The operating principle is that the inner conductor and the inside of the braid act as two opposing bifilar windings with substantial inductance inserted in the outside of the braid. Differential current passes through such a transformer with little insertion loss as the opposing windings of the transformer mode effectively eliminate the winding inductance. If you want to run an unbalanced differential current through the transformer then substantial inductance will be present. Thus the current balun suppresses common-mode current. Since current flowing on the outside of the braid, is referenced to ground it must flow through the impedance resulting from the winding inductance formed by the outside of the braid and the core. This inductance will reduce the current if the impedance is high enough.

The same principle applies in the common-mode choke where two or more wires pass through a ferrite core. A typical example is seen in the ferrite chokes clamped on the monitor cable of computers.

High permeability cores can be used for current-mode baluns or common-mode chokes as there is not net magnetic field around the bifilar winding even though substantial currents are flowing.

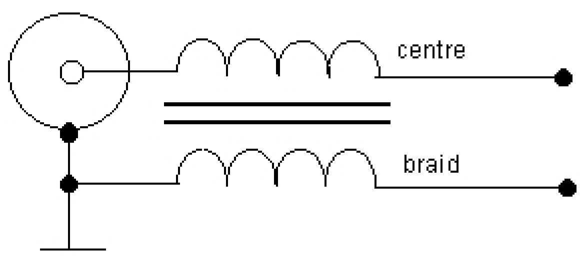


Figure 1 - Schematic

Construction

A ferrite rod is easier to wind and cheaper than a toroid. At 160m I found that I needed 30 turns of RG58 U/C to ensure that I obtained equal, but opposite current, in each leg of an asymmetrically mounted dipole. To place 30 turns you will need to wind more than one layer across the core. The turns can be held by insulation tape and by applying two cable ties on the ends of the last layer. One end of the coax is terminated in a connector while the braid and centre conductor are split out and used as the balanced feed at the other end. You should use coax with adequate breakdown voltage to avoid damage when operating into mismatched loads.

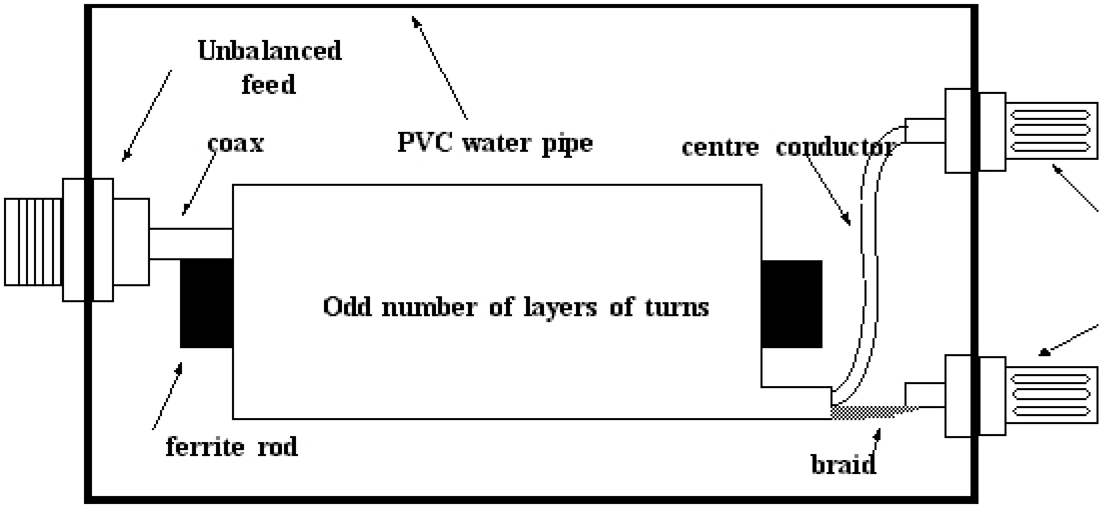


Figure 2- Construction details for 1:1 balun

Housing

The balun can be housed in PVC water pipe. Cut a section large enough to make two end pieces which can be flattened with the aid of the hot air from a hair-drier or heat-gun. The circular end-sections can be cut with tin-snips. I drilled a hole for a panel-mount connector in one end and used banana connectors for the balanced feed on the other end. The end sections should be inserted inside each end of the pipe and held in place with the PVC glue. I have found hot-melt glue adequate and easily removable. Extra protection is obtained for the ends if you leave an overhang by inserting the ends further into the pipe. My balun has survived several four-wheel-driving desert trips and is still intact and operating after five years.

Reference

1. *HF Antennas for All Locations, Les Moxon, G6XN, RSGB.*

Related articles

- Guanella, a 1:4 Current-mode balun.

Email: Ralph Holland
Url: http://www.arising.com.au

Last modified Saturday, 4 April 2015 17:29

40 pf trim cap

1N5262B

LED

1N4148

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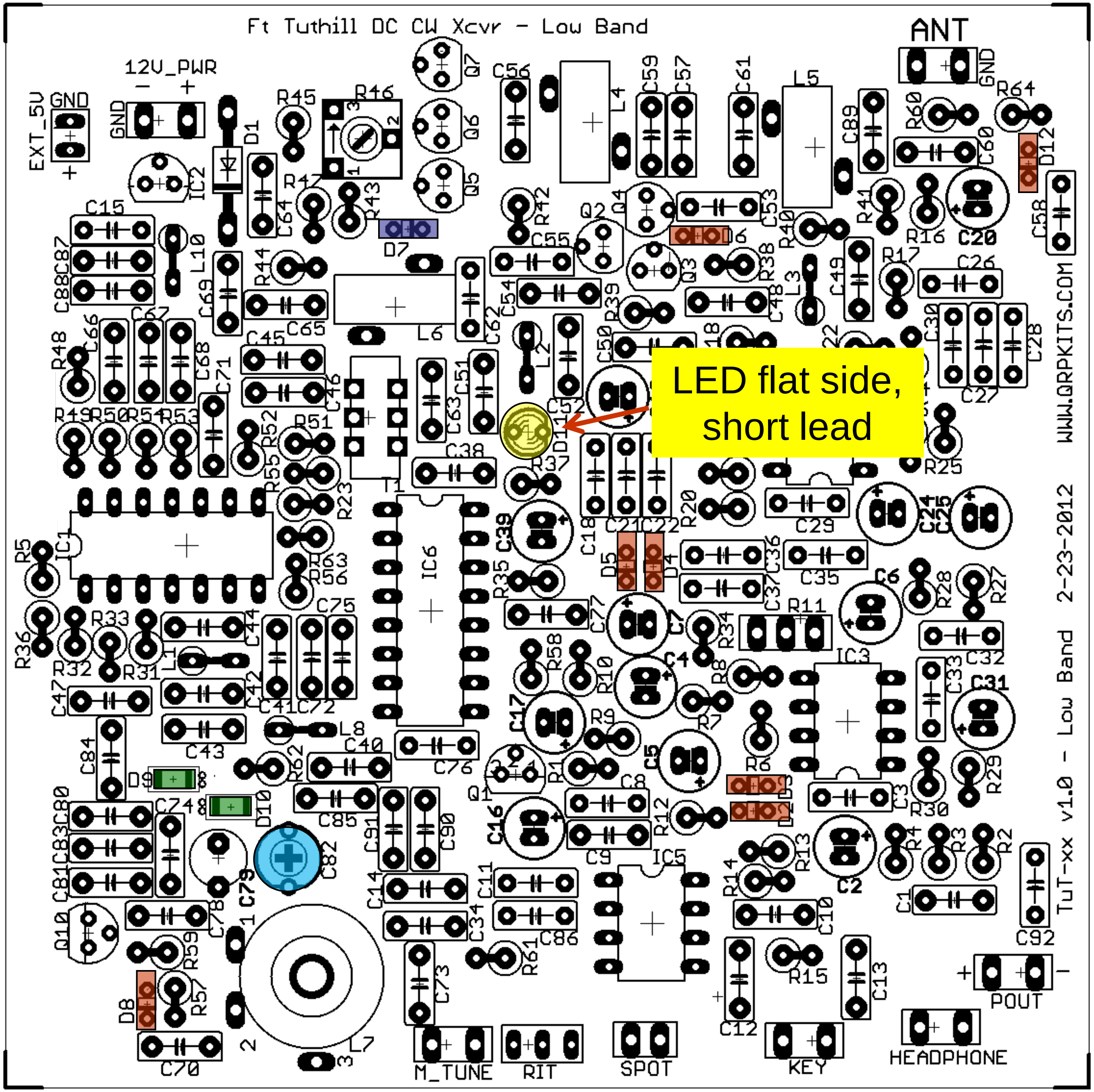
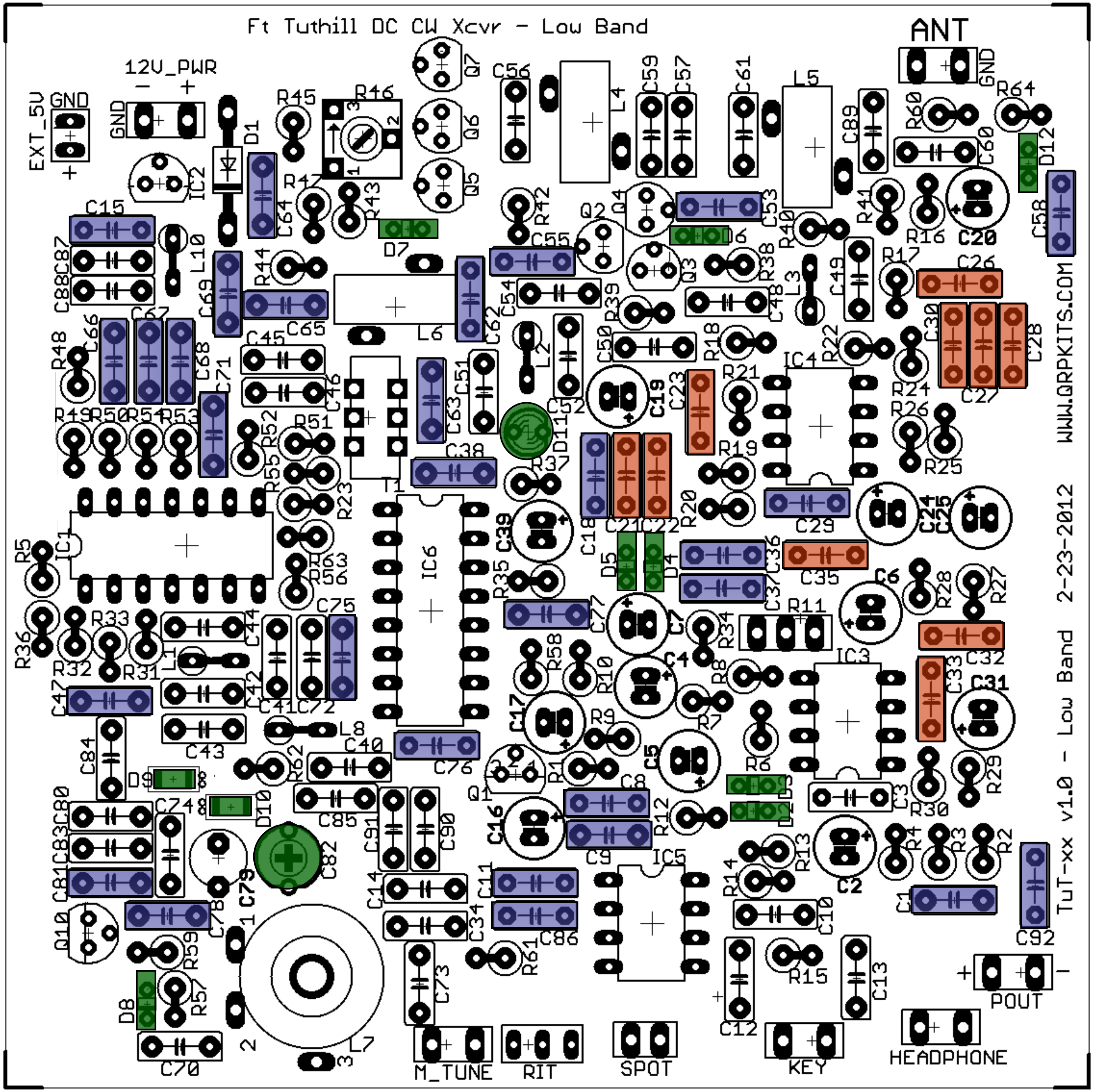


0.1 uf

Matched Filter Caps 0.1 uf



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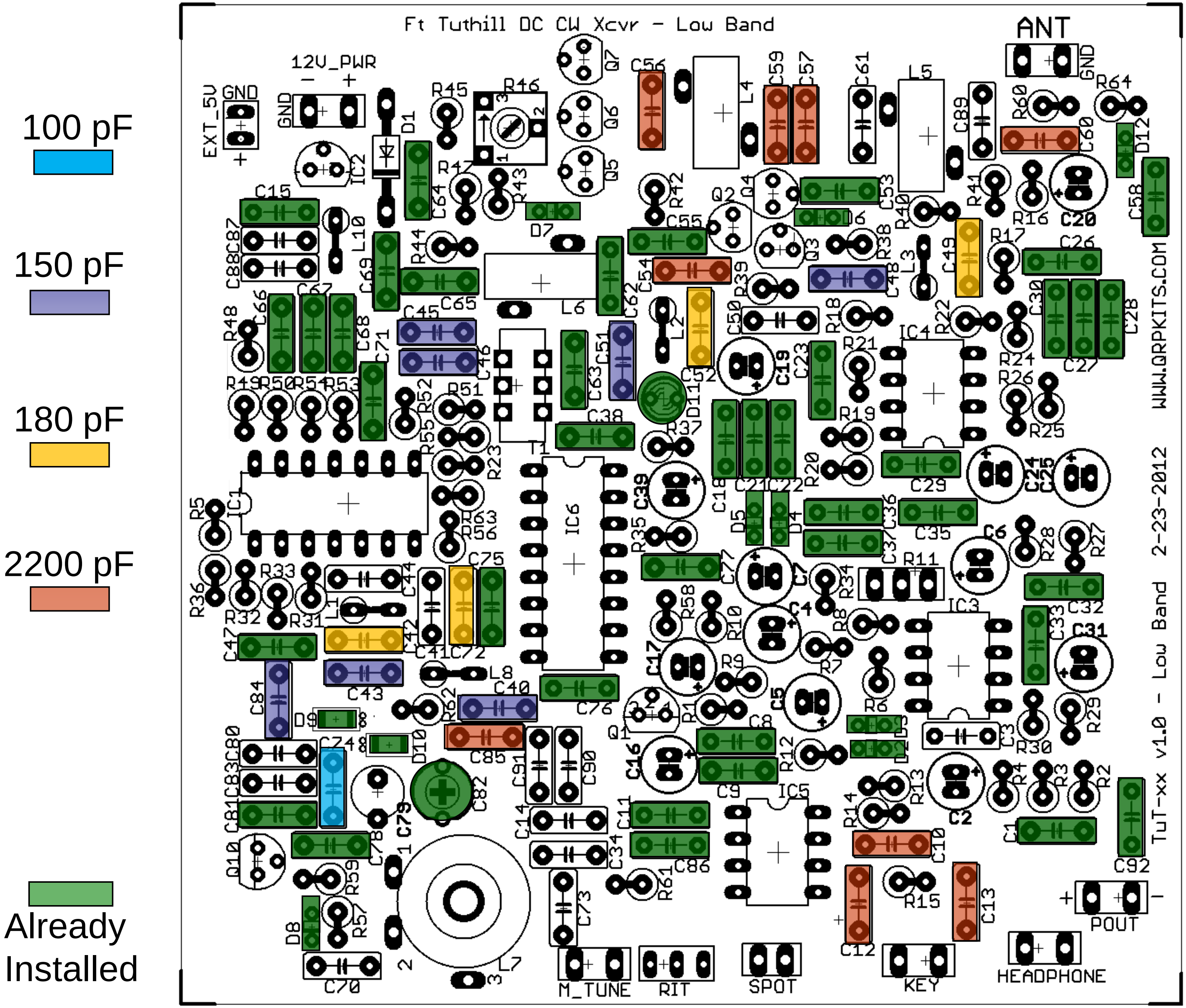
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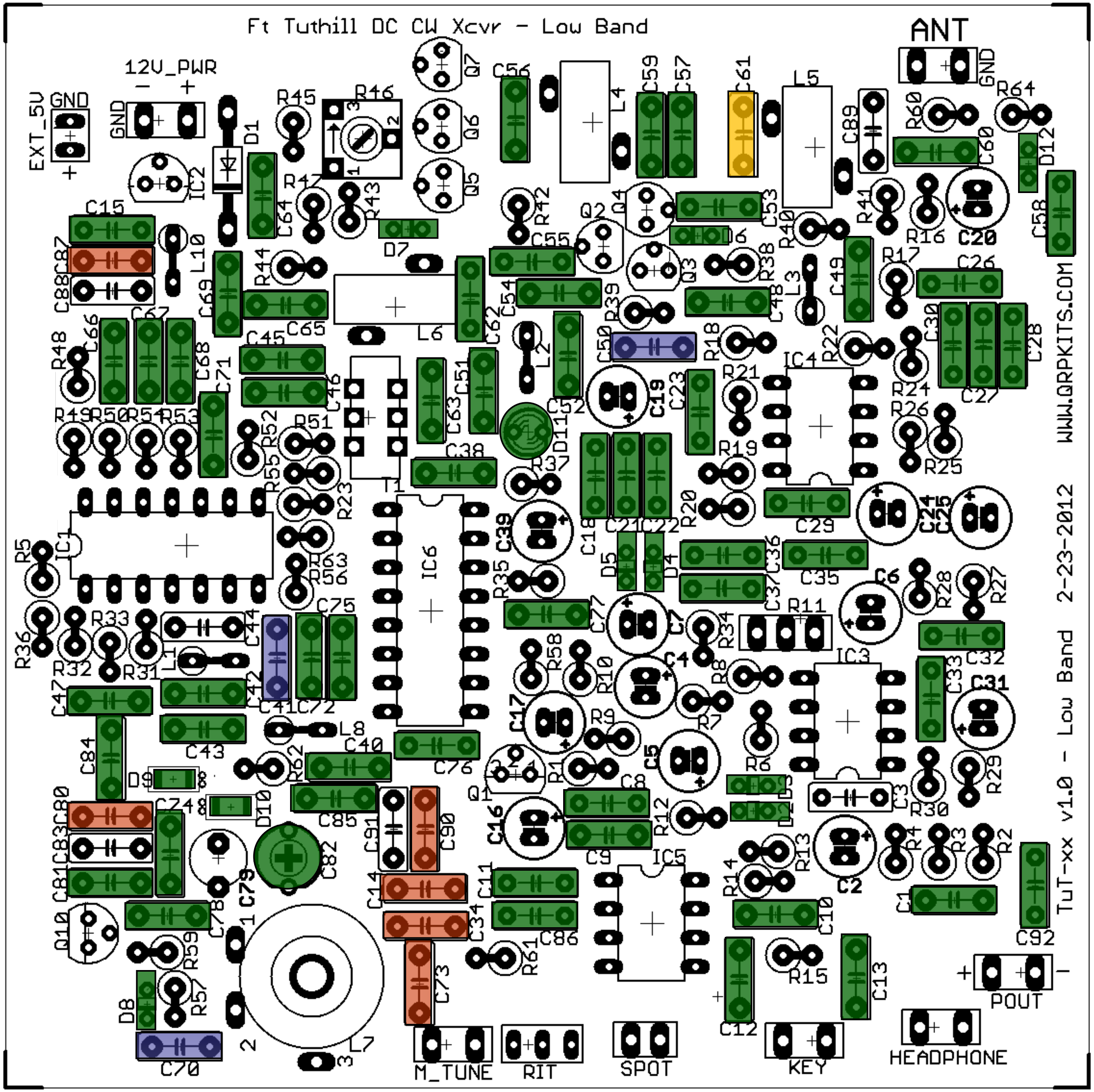
270 pF

820 pF



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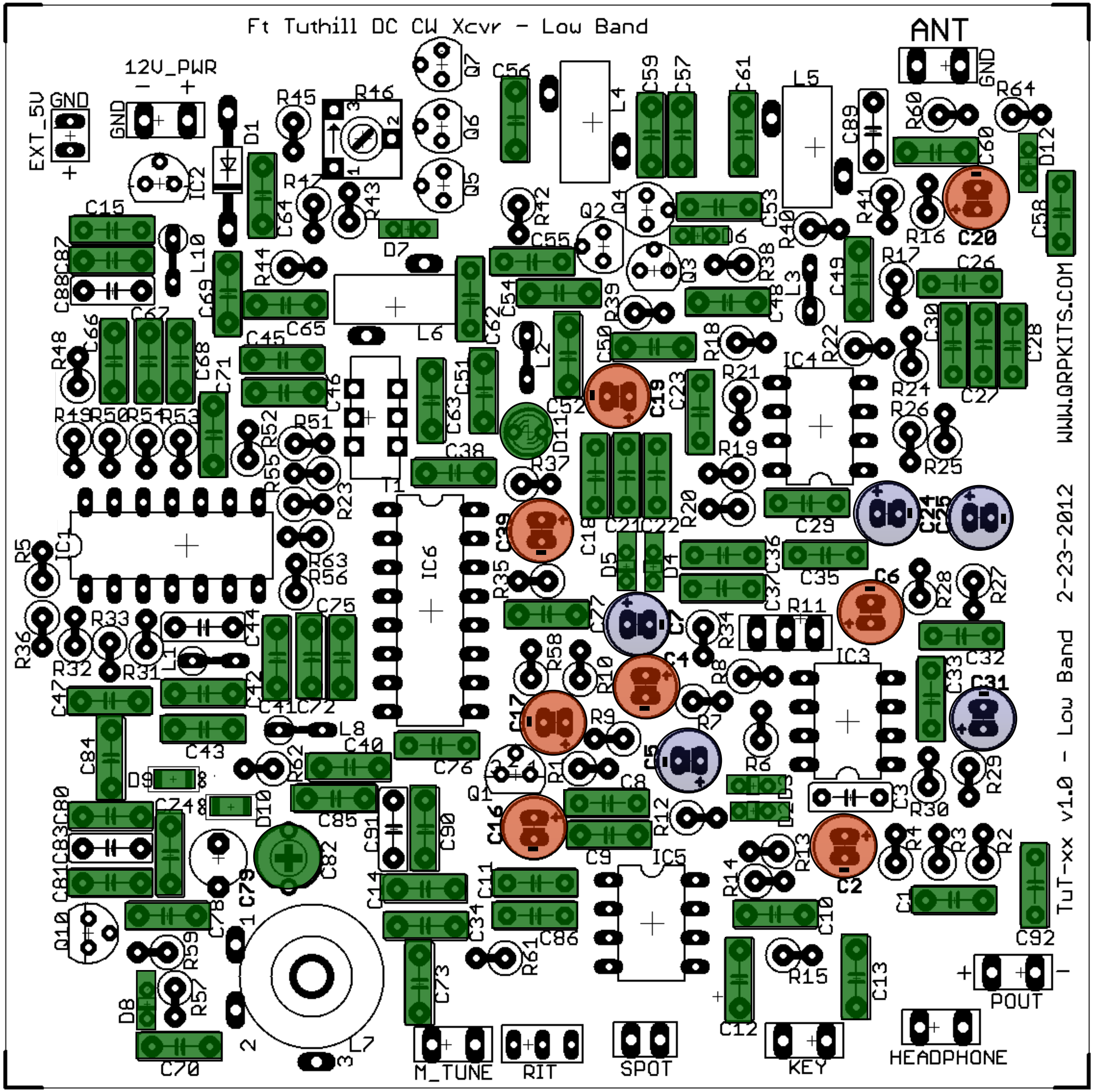


2.2 uF

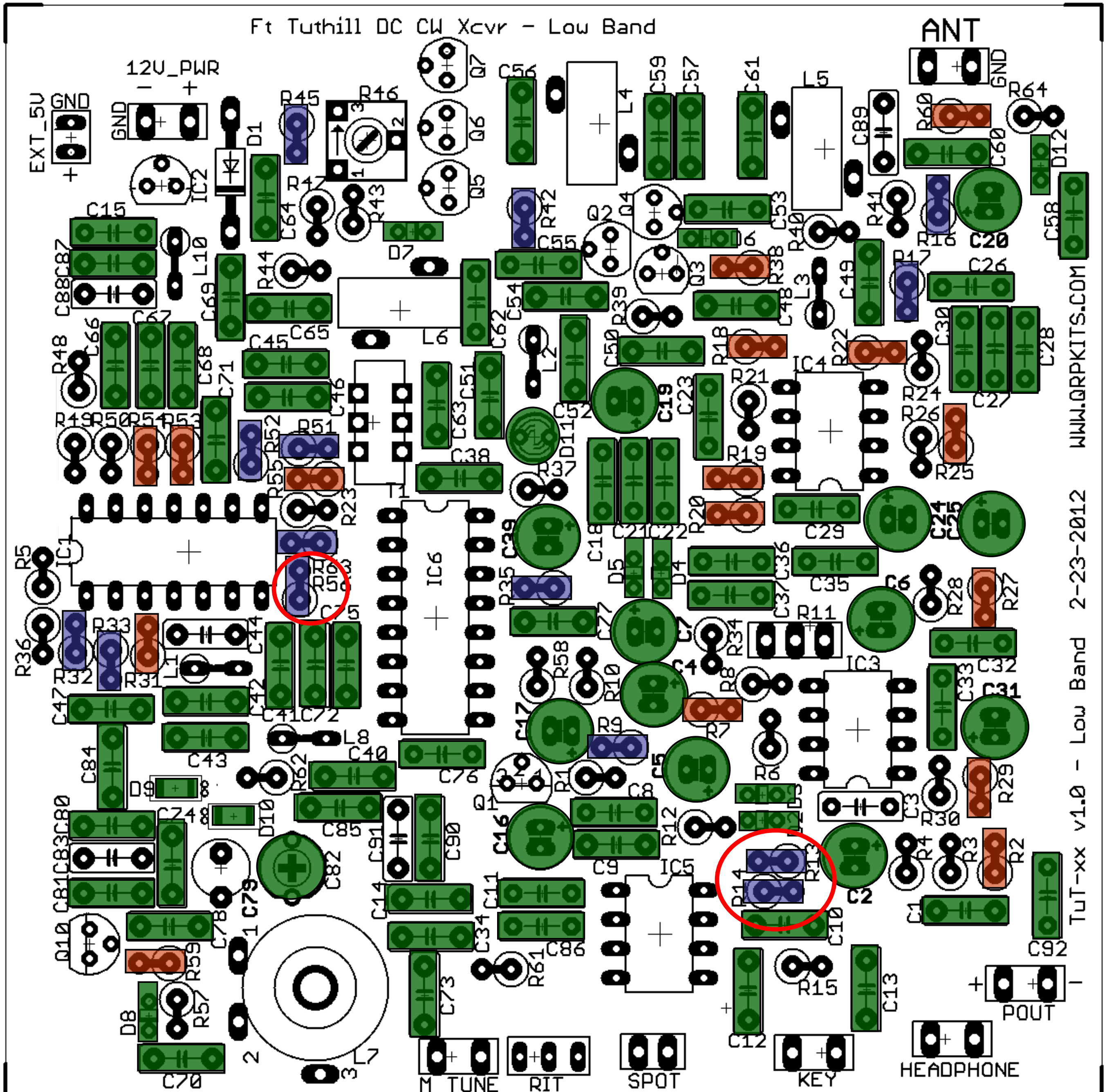
33 uF

Already Installed

22K

1K

Double check direction of red circled resistors



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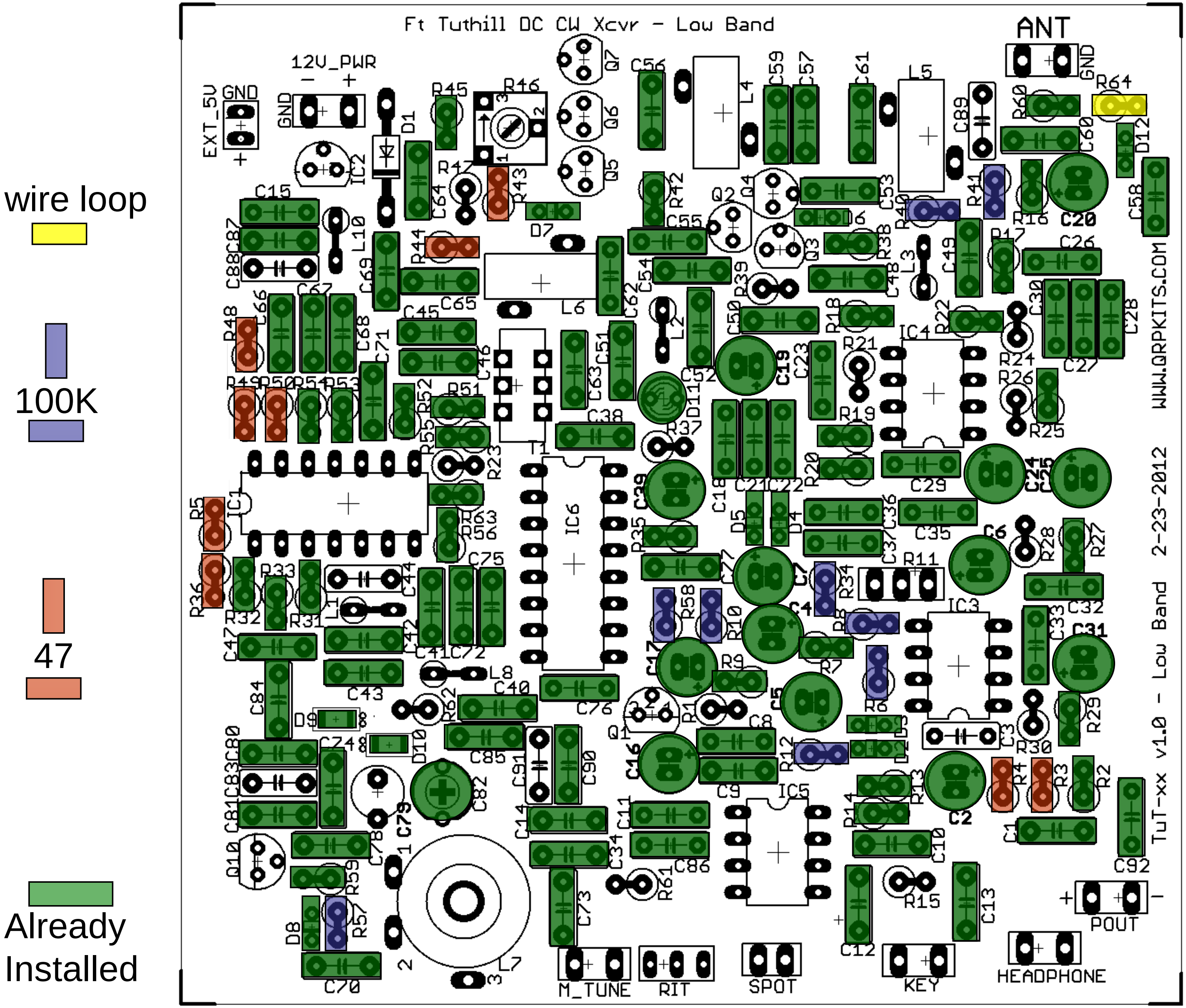
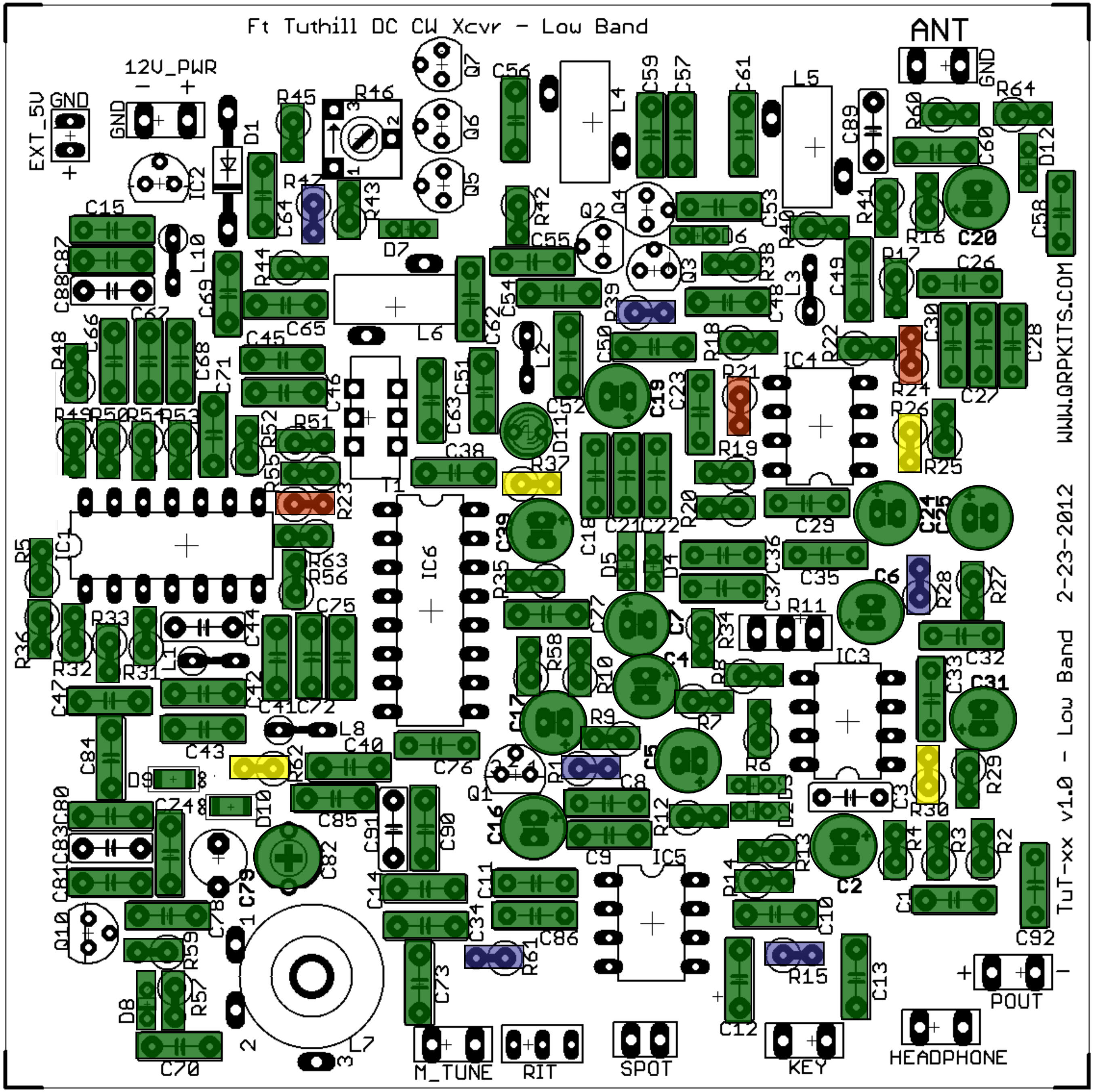

Ft Tuthill DC CW Xcvr - Low Band
ANT
12V_PWR
EXT_5V
GND
M_TUNE
RIT
SPOT
KEY
HEADPHONE
POUT
WWW.QRPKITS.COM
2-23-2012
TuT-xx v1.0 - Low Band
wire loop
100K
47
Already Installed

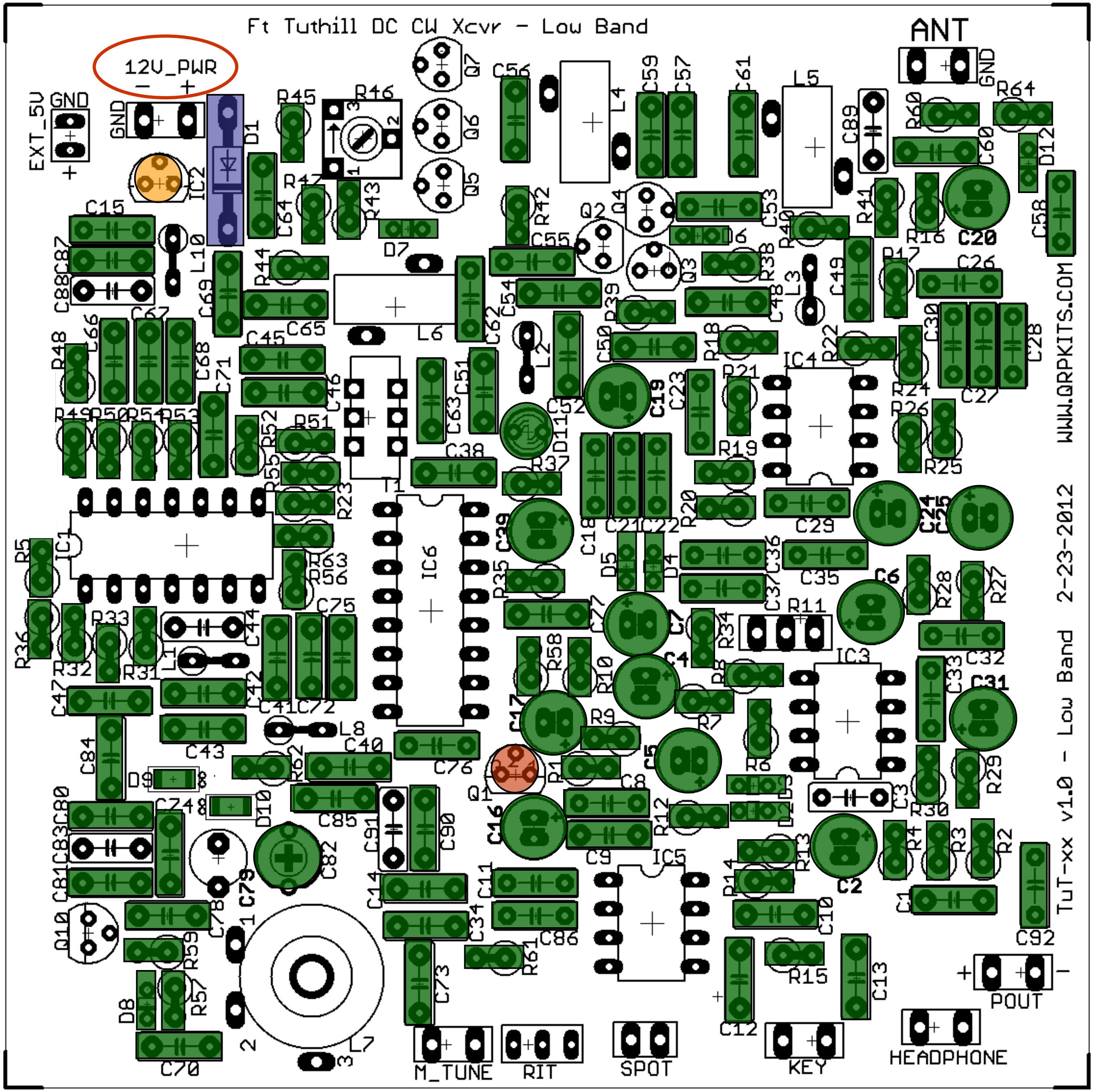
3.3K

2.7K

4.7K

Already Installed





1N4001

2N3904

78L05

Already Installed

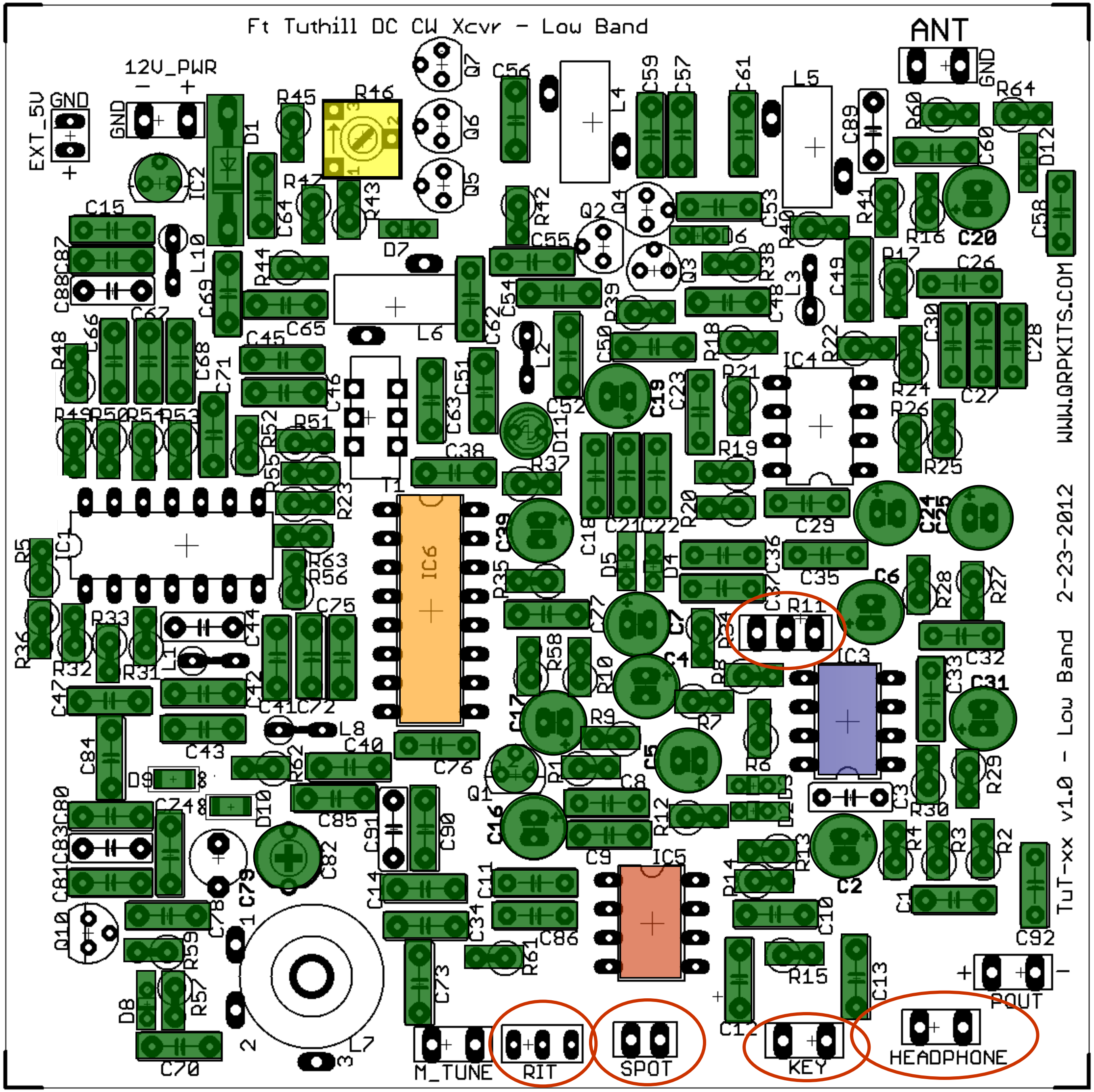
5532

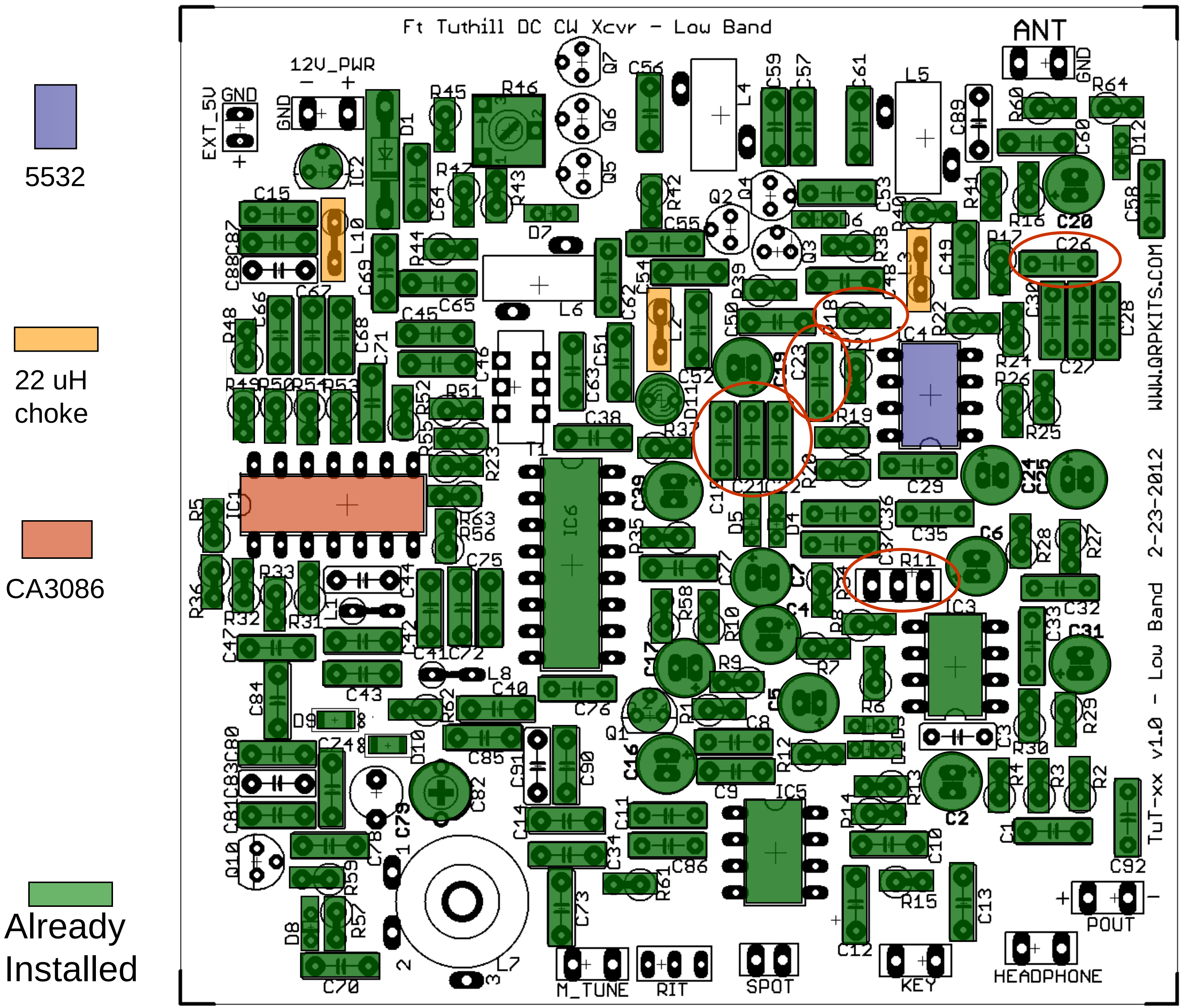
PIC12F508

74HC4053

10K Trim Pot

Already Installed

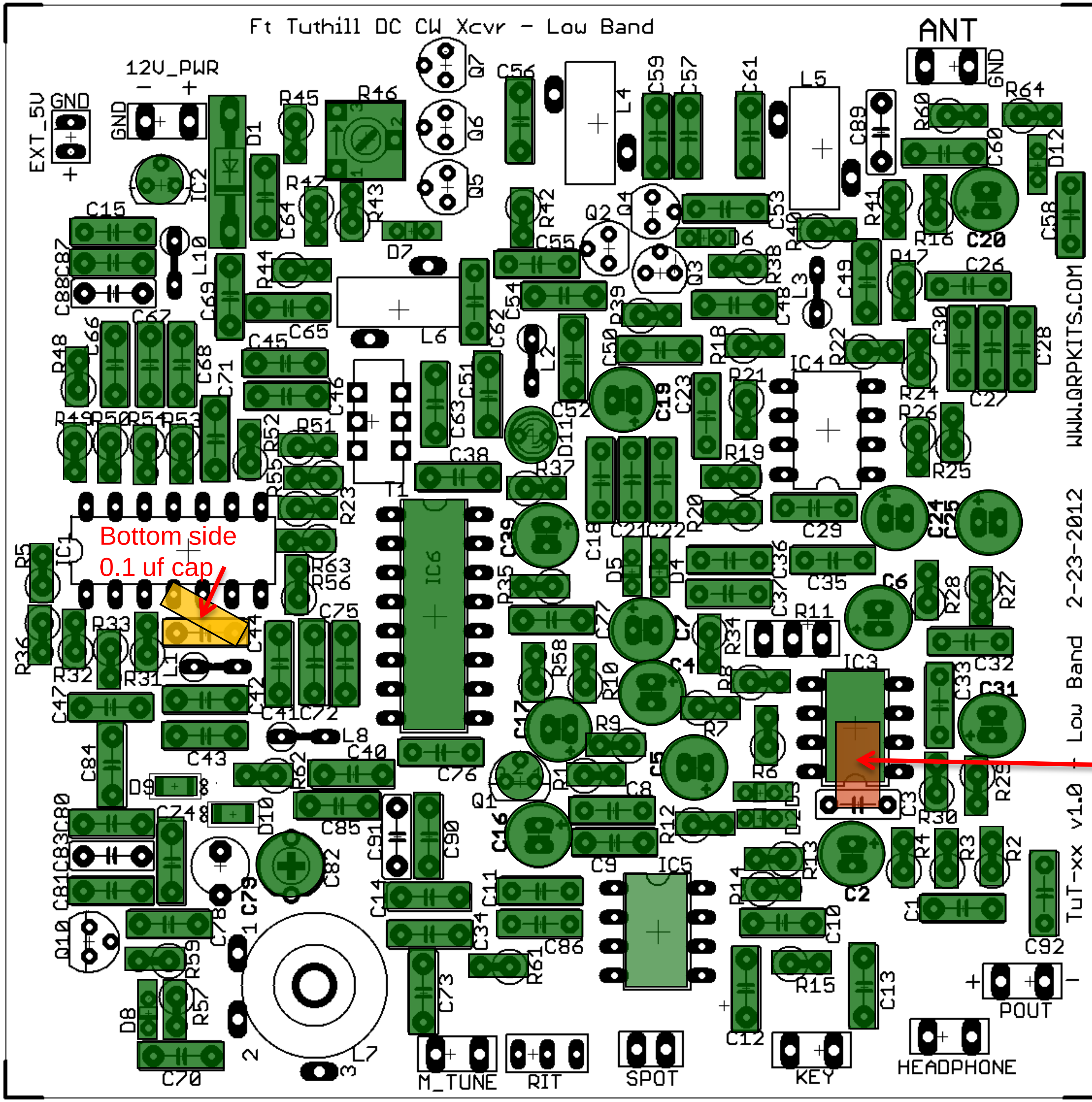



5532
22 uH
choke
CA3086
Already
Installed
Ft Tuthill DC CW Xcvr - Low Band
ANT
GND
12V_PWR
EXT_5V
WWW.QRPKITS.COM
2-23-2012
TuT-xx v1.0 - Low Band
M_TUNE
RIT
SPOT
KEY
HEADPHONE
POUT

220 uF

0.1 uF

Already Installed



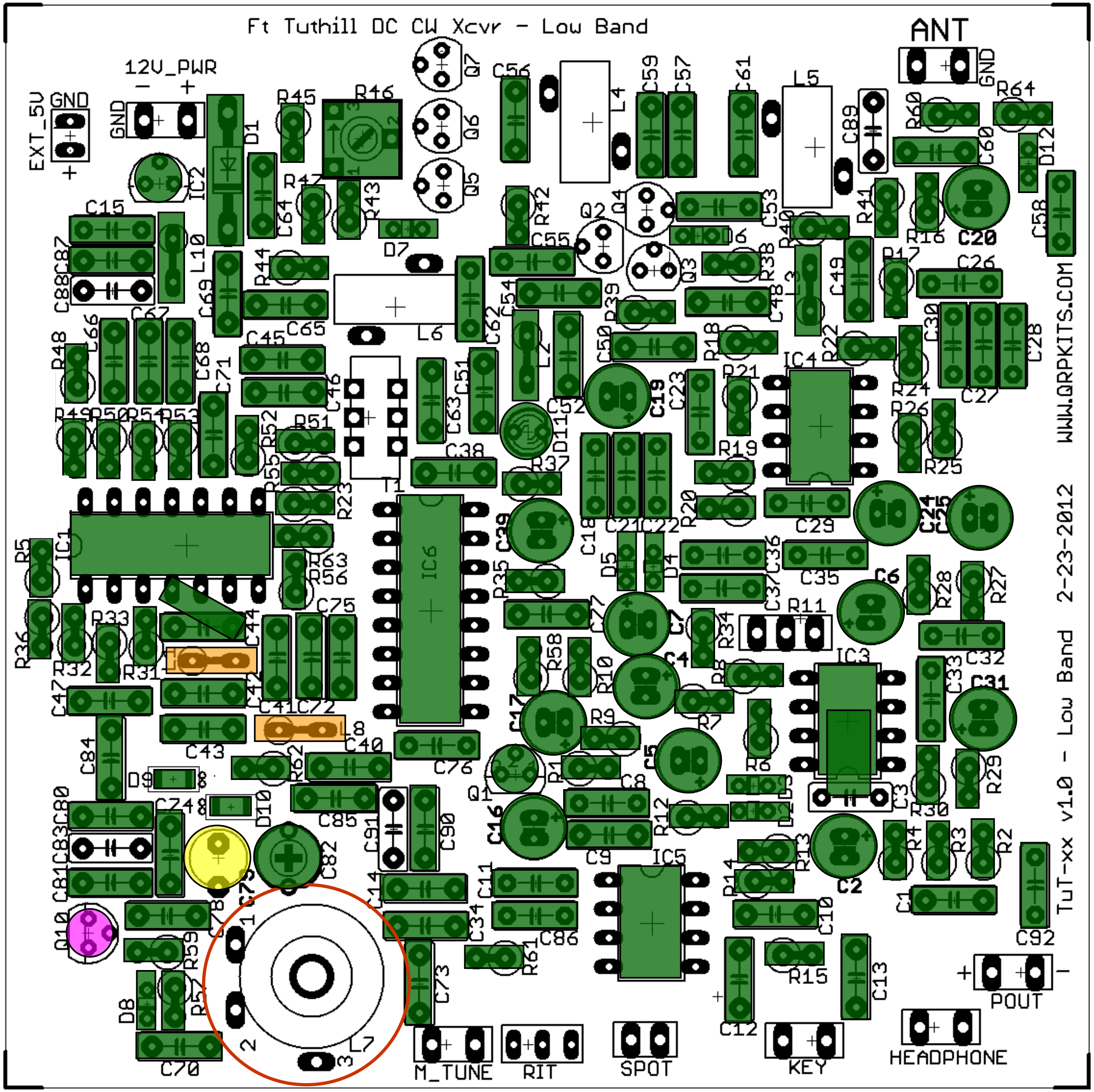
Top side
220 uf cap

22 uH choke

1000 pf poly

2N5485

Already Installed



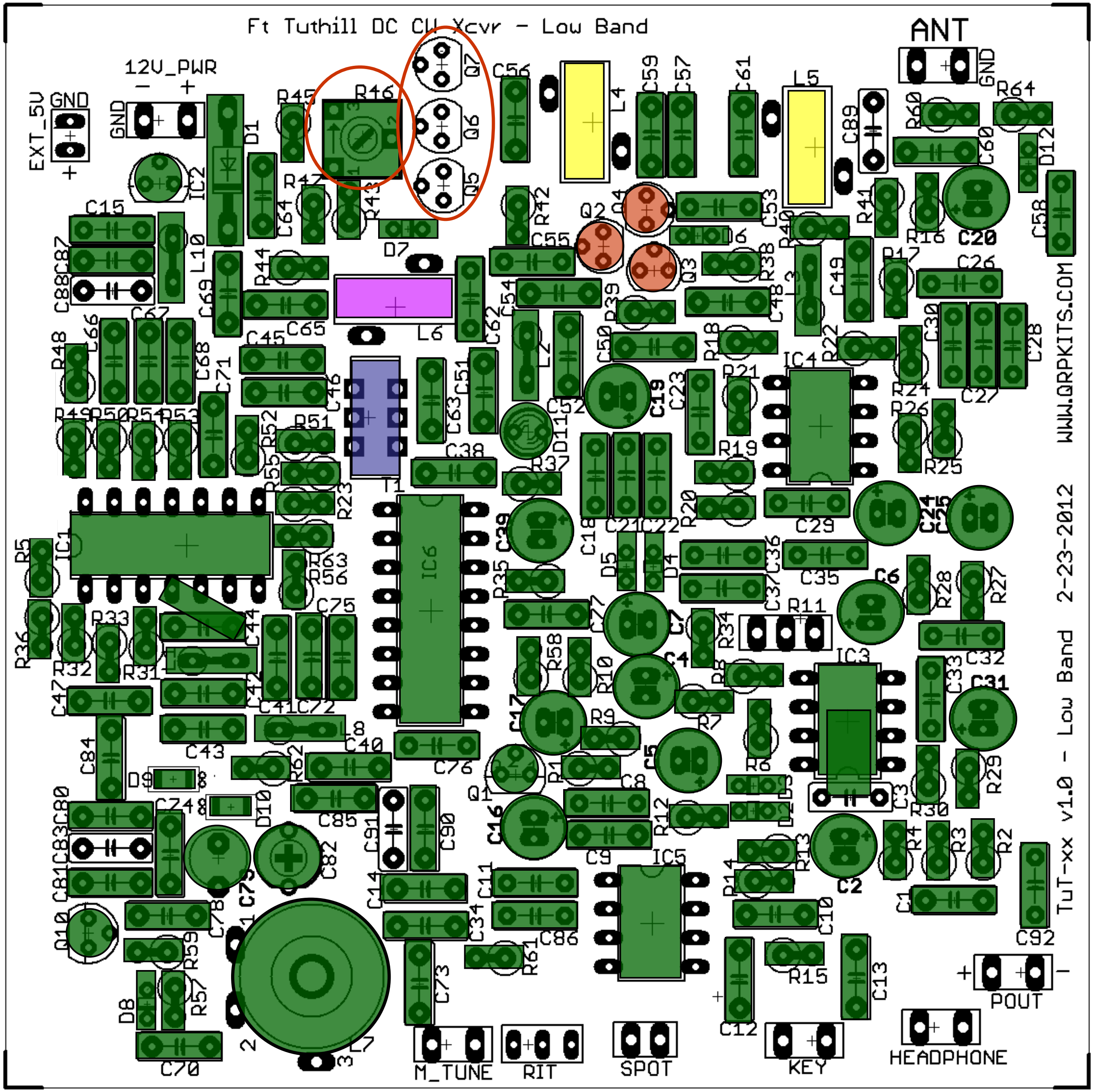
L6

T1

BS170

L4, L5

Already Installed



900 MHz CMOS RF-to-DC Converter Using a Cross-Coupled Charge Pump for Energy Harvesting

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***Abstract* — This paper presents a CMOS RF-to-DC converter with a cross-coupled charge pump for energy harvesting. The proposed RF-to-DC converter consists of a cross-coupled rectifier and a cross-coupled charge pump. The charge pump can operate with a non-overlapping clock with a switching frequency of 25 MHz using a pump capacitance of 4 pF. The RF-to-DC converter IC was designed and fabricated using a 0.13 µm CMOS process. An output voltage of 2.05 V was achieved at an RF input power of -6 dBm with an input frequency of 900 MHz and the load of 100 KΩ. For this condition, the charge pump exhibited a high efficiency of about 74 %.**

***Index Terms* — CMOS RF-to-DC converter, charge pump, energy harvesting, rectifier, ultra-high frequency (UHF).**

I. Introduction

Batteries have a limited life time and hazardous chemicals. Finite battery life drives many researchers to propose new ideas for the wireless systems including energy harvesting [1]. There are many interesting ways for energy harvesting from the ambient sources, such as light, heat, vibration, RF, and so on. Among all, RF signals are available everywhere as well as every time [2]-[3].

An RF-to-DC converter is very important for the energy harvesting devices using RF signals. It generates stable DC power with an appropriate voltage level which is required by the target devices [4]. Conventional RF-to-DC converter uses a Dickson's circuit [5]. An RF-to-DC converter based on Dickson's circuit suffers from efficiency drop due to the turn-on voltage of the diode. Especially for the integrated circuit, a MOSFET diode has to be generally used to design the circuit, because an additional processing step is required to provide a Schottky diode which has very low turn-on voltage [6]-[7]. In this paper, a CMOS RF-to-DC converter integrated circuit is presented for the 900 MHz band. The proposed RF-to-DC converter has a cross-coupled rectifier based on MOSFET to convert the RF input signal to a DC voltage. It also has a high-efficiency cross-coupled charge pump to boost the low input DC voltage. The cross-coupled structure has advantages in low reverse leakage current and low voltage drop across the MOSFET diode.

II. Circuit Design

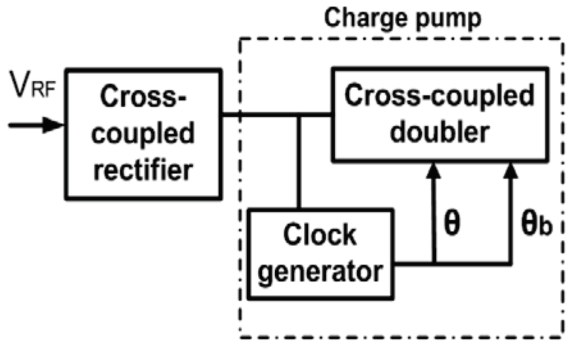

Fig. 1. A block diagram of the proposed RF-to-DC converter

Fig. 1 shows a block diagram of the proposed RF-to-DC converter. It has a cross-coupled rectifier and a cross-coupled charge pump. The rectifier operates at the 900 MHz band. The charge pump operates at a very low frequency of about 25 MHz. The integrated oscillator generates a non-overlapped clock for the charge pump. The rectifier is optimized for a load resistance of 10 kΩ.

A. Cross-coupled rectifier

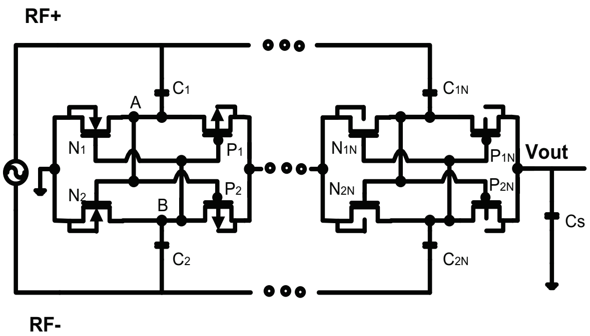

Fig. 2. A schematic diagram of an N-stage cross-coupled rectifier.

Fig. 2 shows an N-stages cross-coupled rectifier [8]. A voltage generated by a single-stage rectifier is not enough to operate the clock generator and the charge pump. Therefore, the rectifier should be designed more than two-stages. A differential RF signal is applied to the input of

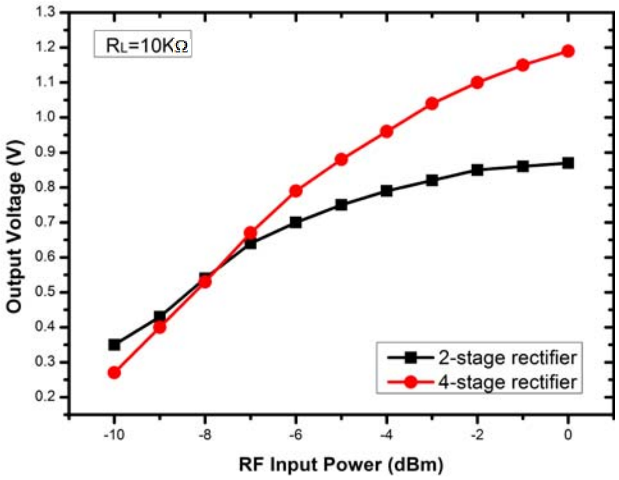

Fig. 3. Measured output voltages of the two- and four-stage rectifiers.

the rectifier. The gates of the NMOSFETs and the PMOSFETs are connected each other. When the node A has a positive signal swing, N1 and P2 are turned on, while N2 and P1 are turned off. The voltage of the first stage is nearly doubled by the peak voltage of the RF signal [9]-[11].

To maximize the RF-to-DC conversion efficiency, the aspect ratio between NMOS and PMOS transistors should be optimized. Channel widths for the NMOS and PMOS transistors were selected to be 30 µm and 42 µm, respectively. Channel length of 0.13 µm for both transistors is selected. Flying capacitors of 0.7 pF were selected for the optimized performance.

Fig. 3 shows the measured output voltages of the two- and four-stage rectifiers according to the RF input power with a load resistance of 10 kΩ. The output voltage of the two-stage rectifier is larger than that of the four-stage rectifier at an RF input power level less than -8 dBm. The four-stage rectifier outperforms and generates more than 0.8 V at the input power of higher than -6 dBm.

B. Charge pump

Fig. 4 shows the cross-coupled charge pump, which is composed of clock generator and cross-coupled doubler. Typical Dickson's charge pump has limited performance due to turn-on voltage of the MOSFET-based diode and reverse charge sharing. However, the cross-coupled charge pump has better efficiency due to a cross-compensation of the threshold voltage. Fig. 4(a) shows a two-stage gate cross-coupled doubler. Fig. 4(b) shows a clock generator using an inverter chain. In the charge pump design, switching frequency, load condition, flying capacitor, channel width of the transistors, and dead time of a non-overlapping clock should be carefully considered [12].

Fig. 5 shows the simulated clock frequency according to the bias voltage. The clock generates non-overlapping clock signal with a short dead time. For the bias voltage of 0.8 V, the clock generator generates a non-overlapping clock with a frequency of 25 MHz.

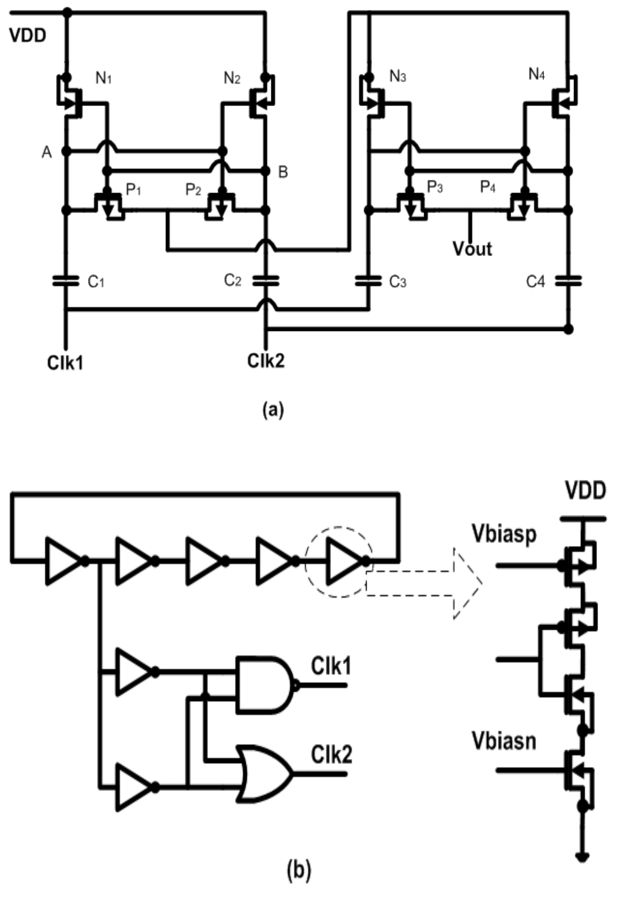

Fig. 4. A schematic diagram of the charge pump circuit: (a) cross-coupled doubler, (b) clock generator.

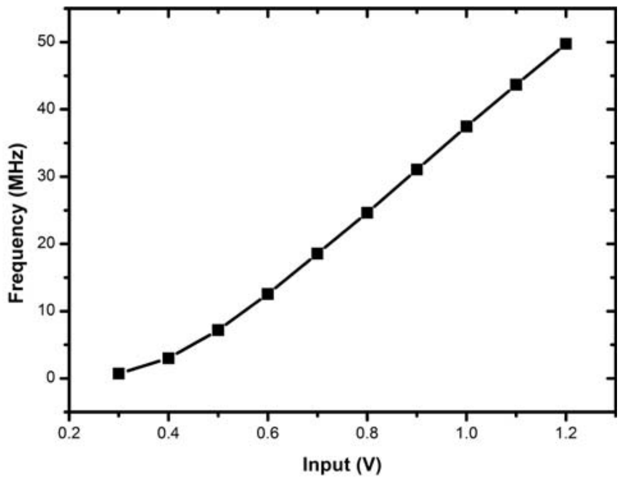

Fig. 5. The simulated clock frequency according to the bias voltage

Fig. 6 shows the simulated and measured PCE according to the input DC voltage. The measurement was carried out with a load resistance of 10kΩ. The

integrated charge pump has a good efficiency which is more than 60 % at input voltages of more than 0.6 V. The implemented charge pump exhibited a very high peak PCE of 74 % at an input voltage of 0.8 V.

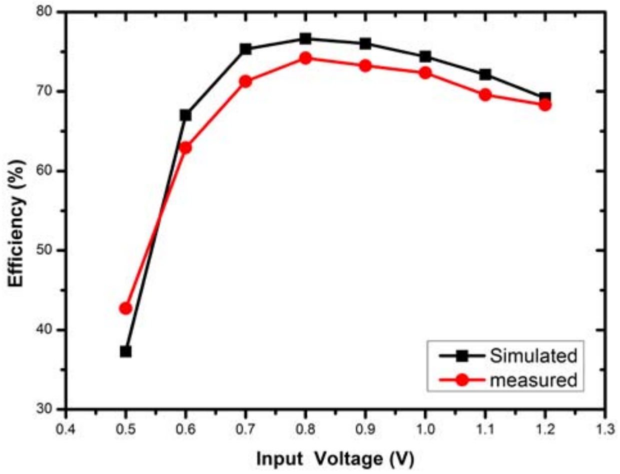

Fig. 6. The simulated and measured performances of the implemented charge pump.

III. Experimental Result

Fig. 7 shows a photograph of the fabricated RF-to-DC converter IC whose size is 400x512 μm^2. The chip was designed and fabricated using Dongbu's 0.13 µm CMOS process. An RF input signal from the signal generator having a frequency of 900 MHz is applied to the proposed RF-to-DC converter IC via a transformer for differential signal excitation. Then, the output voltage was measured through an oscilloscope.

Fig. 8 shows the measured output voltages of the RF-to-DC converter IC with two-stage and four-stage rectifiers with a load resistance of 100 kΩ. The RF-to-DC converter with a four-stage rectifier has better performance at an input power level of more than -7 dBm.

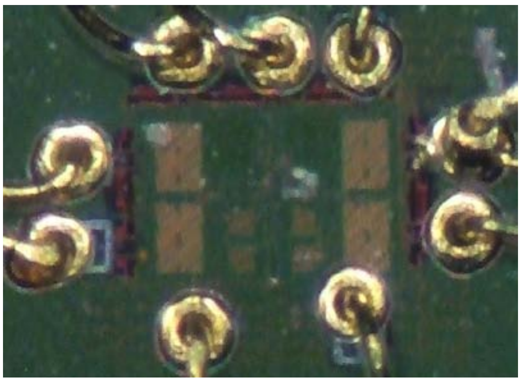

Fig. 7. A photograph of the fabricated RF-to-DC converter IC.

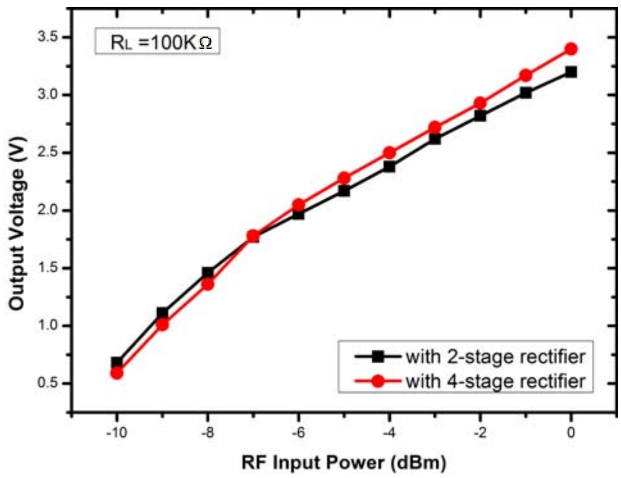

Fig. 8. The measured output voltages of the RF-to-DC converters based on the two-stage and four-stage rectifiers.

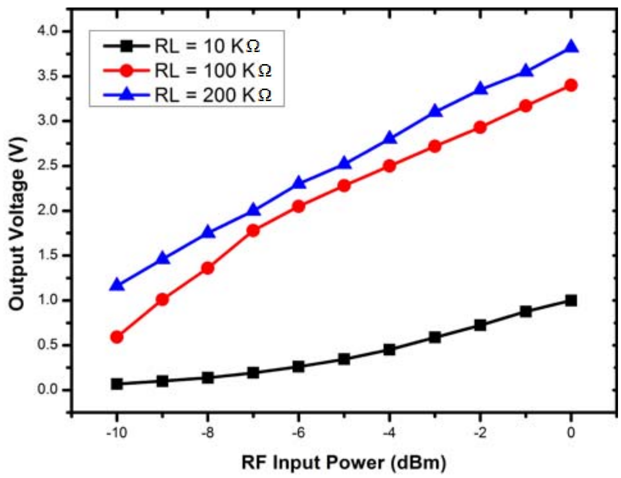

Fig. 9. The measured output DC voltages as a parameter of the load resistances.

Fig. 9 shows the measured output voltage as a parameter of the load resistances for the RF-to-DC converter with a four-stage rectifier. With a load resistance of 100 kΩ and an input power of -6 dBm, PCE's of the RF-to-DC converter and the charge pump are 24 and 74 %, respectively. The output voltage for this condition was as high as 2.05 V.

IV. Conclusion

In this paper, an RF-to-DC converter using a charge pump for RF energy harvesting is presented for the 900 MHz band. It consists of a cross-coupled rectifier and a cross-coupled charge pump with a clock generator which generates non-overlapping anti-phased clock signal. The voltage drop and reverse leakage current of the transistor is minimized using the cross-coupled circuit configuration. A high output voltage is achieved using a charge pump which operates with a non-overlapping clock whose frequency is about 25 MHz. The implemented RF-to-DC converter exhibited an output voltage of as high as 2.05 V

at an RF input power of -6 dBm with a load resistance of 100 kΩ. This CMOS RF-to-DC converter can be applied to an RF energy harvesting systems.

ACKNOWLEDGEMENT

The chips were design with Cadence and fabricated Through the IC Design Education Center.

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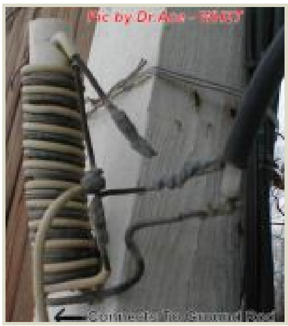
How To Make A High Power 4:1 Balun



Homebrew 4:1 Balun

How To Make A High Power 4:1 Balun Info

I built a homebrew 75 meter
Double Extended Zepp Antenna,
And I needed a 4:1 Balun , so I decided to Homebrew the Balun also.
Here is how I did it!

I used a 5 inch long piece of PVC Plastic pipe about 5/8 ID and about 7/8 OD , 1 inch OD will work fine.
I wound 12 bifilar Turns using 10 Gauge Solid insulated copper wire, but you can use 12 or 14 Gauge.

I recommend using two different color wires.
I used Black and White from an old piece of 10 Gauge Romex house wire.
If you use 10 Gauge wire the Balun will handle the legal power limit!

Connect the top end of the black wire to the bottom end of the white wire.

This connection point will also connect to the coax shield and ground wire.

Optional - You can also connect a heavy wire as short as possible from this connection point to a ground rod and/or ground system,
A short piece of ½ inch coax with the center and shield connected together at each end would work great.
This puts the whole antenna system at DC ground potential.

Connect one side of your open wire feedline or 450 ohm ladder line etc. to the Top wire "white wire in picture below"
Connect the other side of your open wire feedline or 450 ohm ladder line etc. to the Coax Center and Bottom Wire "black wire in picture below"

After winding the coil I recommend coating it with several coats of clear spray paint “available at Wal-Mart for about $1.00 a can.

This 4:1 balun will work fine from 10 thru 160 meter bands.

NB: There is NO open wire feedline or 450 ohm ladder line etc. connected to the Balun in the picture.

I currently use a 75 Meter Full Wave Delta Loop on the 6 thru 75 Meter bands with a tuner.
I am very pleased with it!, I also currently use a 160 Meter 1/4 wave inverted L antenna.
It will also tune 6 thru 160 meter bands

« back | print

THE HANDYMAN'S GUIDE TO OSCILLOSCOPES (Part 1 of 2)

by Paul Harden, NA5N

Print as .pdf file
5 pages
8½ x 11 or A4

Getting Acquainted with your Scope and making some measurements

Updated May 2004 with actual oscope waveforms

When in the course of human events, it becomes necessary to look at neat signals floating around your radio, you go to a hamfest and buy that $50 o-scope. Now what? This two part article will attempt to explain basically how an oscilloscope works, operator functions, basic measurements, and some advanced applications. An o-scope is a powerful tool in any shack – even a real "cheapie" with limited bandwidth.

HOW AN OSCILLOSCOPE WORKS

A block diagram of a typical o-scope is shown in **Fig. 1**. The test probe usually plugs into the scope via a BNC connector, then passes through a switch to determine whether the input signal will be dc or ac coupled (to remove any dc component). Often this switch will have a "ground" position for setting the zero-volts reference. Next is the input attenuators. The vertical input amplifier is quite sensitive, designed for 20-50mV of input. For larger input voltages, the signal is applied to attenuators comprised of simple voltage dividers. This is the first area of concern for cheap o-scopes, as the input attenuators may not be very linear or accurate. For example, if you appy a 10Vpp signal on the 10v/division setting, the signal should be 1 division high. Switching to 1v/div., the signal should be 10 divisions (usually full-scale) high. If it is not exactly 10 divisions, the attenuator for that setting needs adjusting. Some scopes have internal adjustments for fine-tuning each attenuator setting.

Following the attenuators, the signal is applied to the first vertical amplifier, which converts the input to a differential signal. This differential signal is amplified up to high voltages for the oscilloscope deflecting plates – moving the beam up and down (in the vertical axis).

The sweep generator is usually a constant current source charging a capacitor to make a sawtooth waveform that eventually deflects the beam in the horizontal axis. The frequency of the sawtooth determines how fast the beam travels from the left to the right side of the tube, and is controlled by the sweep control, usually calibrated in seconds, milli-seconds or micro-seconds per division. This is the second area of concern for an oscilloscope – how linear the sawtooth waveform is generated. For example, a sawtooth with a nonlinear ramp will cause the signal displayed in the central portion of the tube to be expanded or compressed compared to the signal at the ends.

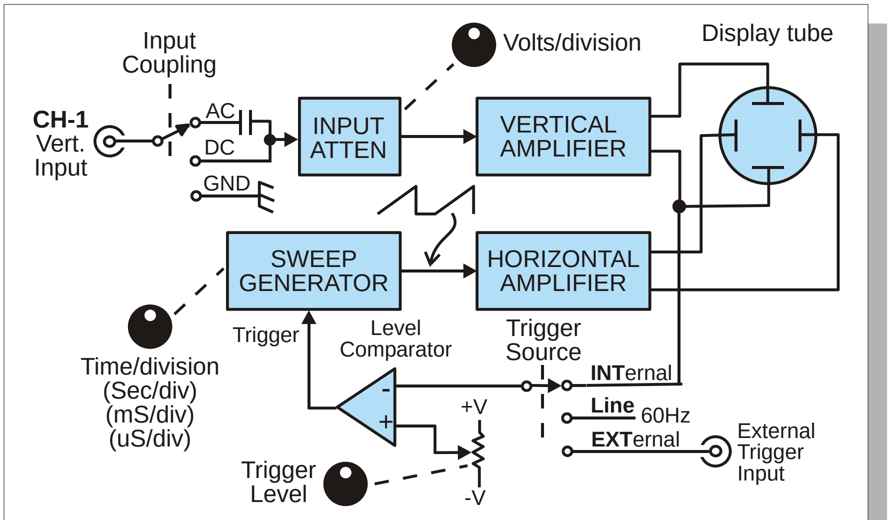


FIG. 1 - Basic block diagram of an Oscilloscpe

The sawtooth ramp is amplified to high voltages, applied to the oscope tube, to deflect the beam from left to right. An important task of an oscope is when the horizontal deflection begins. Normally a switch labeled "Trigger Source" determines what initiates the sawtooth ramp. In the "Internal" position, a sample of the input signal (in the vertical amplifiers) is sampled, with a variable resistor setting the level. When the input signal exceeds the "Trigger Level," a pulse is generated to start the sawtooth ramp and hence the horizontal sweep. The purpose of triggering is to keep the input waveform synchronized to the sweep so it appears stationary on each sweep. The trigger source usually has a "Line" position, which simply triggers the sweep off of 60Hz from the power supply. This synchronizes the sweep to the AC power frequency and is useful for checking television signals, which are synchronized to the power mains. Also, an "External" position may be present, which connects an external input signal (via a BNC connector) to trigger the sweep generator.

Other features your oscope may have are two vertical channels for dual trace operation, various modes to display both waveforms (alternate, chopped, A+B added, etc.), delayed sweep features, dual sweep time bases, built in calibrators, etc.

CALIBRATING YOUR OSCILLOSCOPE

The first thing you should do upon acquiring an o-scope is to check its calibration.

The vertical amplfiers can be checked with a known voltage source or 9v transistor radio battery. Measure the output voltage of the battery with an accurate voltmeter. Let's say it just happens to be +9v exactly. Set the input coupling to ground (0v) and move the trace to the bottom division. Switch the input coupling to DC and set the attenuators to 1v/div. The deflection should be 9

divisions. Switching to 10v/div., deflection should be 0.9 divisions. Internal to the oscope (or perhaps accessible from the outside) are adjustments for the vertical amplifier gain. Adjust this for 9 divisions of deflection in the 1v/div. range. Procedure can be repeated with a 1.5v flashlight battery (assuming you know the exact voltage from a DVM).

The horizontal amplifiers should be checked/calibrated using a signal generator. For example, a 1MHz signal has a period of 1uS. Setting the sweep rate to 1.0uS/div., a 1MHz signal should take exactly 1 division per cycle. Set the horizontal width control properly to ensure the beam starts at the first division and ends at the last division. If the sweep rate appears incorrect, an internal adjustment (Sweep gain or similar) can be set for proper display of the test signal.

The main operator controls are:

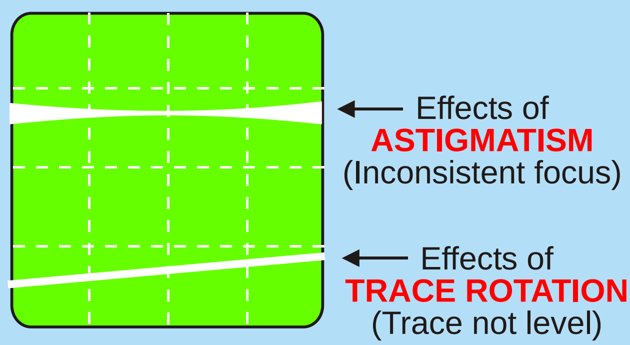
- **Intensity** - controls the brightness of the beam. **NOTE: Too bright a beam can damage to the CRT tube!**
- **Focus** - adjusts the beam for the thinnest and sharpest display.
- **VERT & HOR Position** - controls the vertical and horizontal position of the display respectively
- **VERT V/div** - controls the vertical sensitivity of the display, i.e., how many volts (or mV) per division.
- **HOR Sweep Speed** - sets the horizontal sensitivity, i.e., how many mS or uS per division.
- **VERT & HOR vernier** - allows the vertical and horizontal sensitivity settings to be varied in small steps.

Other adjustments you may find on your scope are:

Astigmatism - With the scope intensity and focus properly set, this adjustment compensates for the curvature of the CRT tube by making it in-focus across the sweep. If your trace is out-of-focus in certain areas, but in-focus elsewhere, the astigmatism needs to be adjusted. See ***Fig. 2***.

Trace Rotation - is a small coil around the CRT that skews the trace to ensure it is perfectly horizontal. On scopes without this adjustment, the trace is leveled by physically rotating the CRT to align the trace to the graticle grid. See ***Fig. 2***.

Fig. 2 – Effects of Astigmatism & Trace Rotation

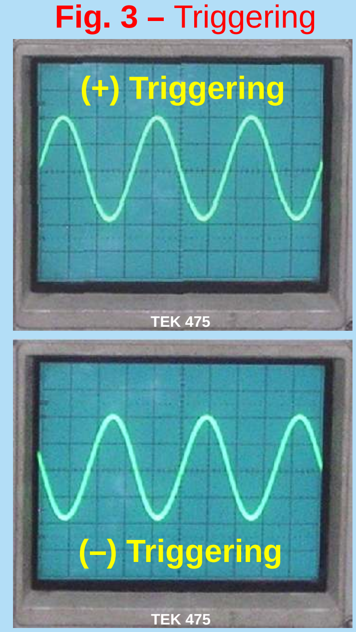


DC BAL (DC Balance) - is a dc offset in the vertical amplifiers that causes a shift in the trace baseline when changing vertical scales. It is most obvious when measuring ac voltages. For example, you are displaying a 10Vpp sine wave, centered on the center graticle, at 2v/div. Changing to 5v/div, the sine wave shifts off the center graticle ... that is, it assumes a dc bias error. The DC BAL is adjusted until the shift no longer occurs when changing vertical scales.

HV ADJ. - is the high voltage that controls the intensity of the trace. Turn up the **Intensity** control to its brightest position, then adjust the HV ADJ for a trace slightly brighter than normal intensity. The **Intensity** control now has the proper range. The HV ADJ might have to be re-adjusted to acquire proper focus.

NOTE: Very bright trace displays can cause permanent damage to the CRT, particularly on a well-used scope.

Fig. 3 – Triggering



LET'S MAKE SOME MEASUREMENTS

It is assumed you have your scope relatively calibrated and familiar with the front panel controls. The sample o-scope displays are based on eight vertical and ten horizontal divisions on the CRT screen, typical to most oscilloscopes. Most waveforms are actual displays of the signal cited, photographed from my trusty Tektronix 475 oscilloscope.

First ... a word on TRIGGERING.

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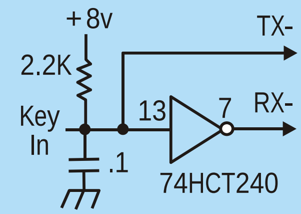
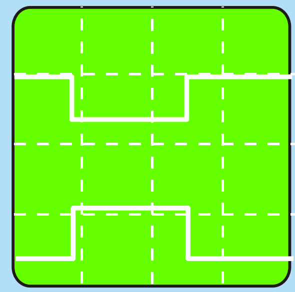


Fig. 4 - 38-Special T-R Switch



VERT: 10v/div DC
HOR: 500mS/div

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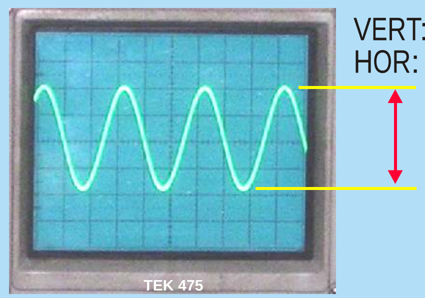
Here is where an oscilloscope pays for itself by making AC voltage (and frequency) measurements. You must remember, AC voltages are displayed on a scope as ***peak-to-peak* voltages**, while a voltmeter measures in ***rms***. RMS voltages are about 1/3 the p-p voltage read on a scope, or specifically:

$$V_{rms} = \tfrac{1}{2}(.707 \times V_{pp}) = 0.354 \times V_{pp}$$

For example, let's measure the output voltage and frequency from the sidetone oscillator in your QRP rig. Place the scope lead on the audio amplifier output. On key-down, you get the waveform shown in ***Fig. 5***. The transmit sidetone audio is 1.9Vpp.



VERT: 0.5v/div ACV
HOR: 0.5mS/div

3.8 divisions
peak-to-peak
times 0.5v/div
= 1.9 Vpp
= 0.67 Vrms

Fig. 5

AC Frequency Measurement.

With this waveform, we might as well see what frequency our sidetone or transmit-offset frequency is. Most operators prefer the sidetone to be about 700–750Hz. Trigger the scope for a stable waveform and set the time-base (sweep) to display 2 or 3 cycles, as shown in ***Fig. 6***. Center the waveform between two horizontal divisions so zero volts on the waveform is on a graticle line, then move the horizontal position so the first "zero– crossing" is also on a division line.

Measure the time it takes to make one complete sine wave from one zero-crossing to the next. In this example, it is 1.5 divisions, at 1mS per division, or 1.5mS. Frequency is simply the reciprocal of time, such that the sidetone frequency is:

$$f = \frac{1}{t} = \frac{1}{1.5mS} = 667 \text{ Hz}$$

For some, this may be about right. For others, this may be a little low to your liking. To raise it to 700Hz, calculate the time period of 700Hz (1/700 = 1.4mS). At 1.0mS/div, you can adjust your sidetone or transmit offset until zero-crossings for a single sinewave is 1.4 divisions. This will be about 700 Hz. (Sidetone may not be adjustable on some rigs).

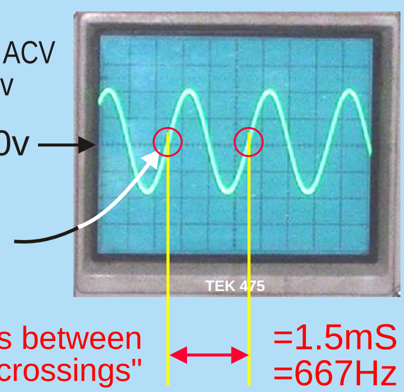
All frequency measurements are made in this fashion, by measuring the distance between zero-crossings (or from one peak to the next) and converting the time period to frequency. This should emphasize the importance of ensuring your sweep speed is calibrated; as any error in the time base will cause a corresponding error in the accuracy of your time or frequency measurements.

Fig. 6

VERT: 0.5v/div ACV
HOR: 0.5mS/div

0v

First "Zero Crossing"



3 divisions between "zero-crossings"

=1.5mS
=667Hz

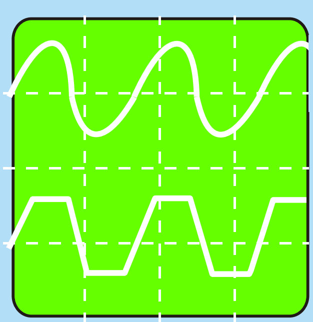


Fig. 7

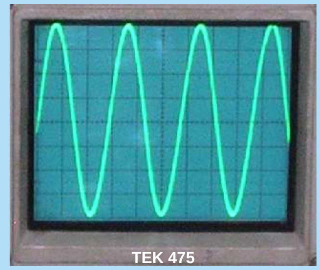
Example of Waveform Quality

VERT: 2v/div ACV
HOR: 1.0mS/div

Quality of the waveform is another feature of a scope that is unsurpassed since you are "seeing" the waveform in real time. Two examples of waveform quality are shown in ***Fig. 7***.

The top trace shows the sidetone frequency with distortion, perhaps due to improper time-constant on the coupling capacitors or improperly biased audio amplifiers. The bottom trace would be a raspy sounding side tone, due to the amplifier being over-driven and in compression (clipping). The o-scope is an invaluable tool for detecting and diagnosing such impurities in the signal quality.

FIG. 8 – Full Scale Signal Display



Actual display Tektronix 475

MORE NIFTY MEASUREMENTS

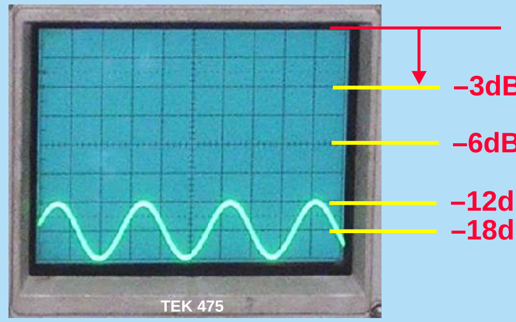
Amplifier Gain.

The gain of an amplifier can be measured in terms of voltage or decibels (dB). For voltage gain, it is simply Vout/Vin of the amplifier. For example, if the input is 1Vpp and the output is 4Vpp, then the amplifier has a voltage gain of 4.

Gain in dB is often more useful and is how the gains of amplifiers are usually expressed. With dB's, every-time you double the AC voltage, you add 6dB of gain. It is the **ratio** of output to the input, and this **ratio** is easy to measure on a scope.

It is often easier to start with the output. Set the vertical amplifier gain to display the amplifier **output** as a full-scale signal as shown in ***Fig. 8***. Now move the scope probe to the amplifier **input** without disturbing the scope gain. You will of course have a much smaller signal, and the ratio of the input to the output will be the gain in dB. In our example of using eight divisions for full-scale, then four divisions would be 6db, 2 divisions 12dB, etc. as shown in **Fig. 9.** You may want to add your own dB scale along your scope display to remind you of this relationship. Note: this is ***voltage gain*** (Av=20log x Vout/Vin). In this example, with 4Vpp output and 1Vpp input (Av=4), then the gain is dB=20log(4) = 20(0.602) = 12dB, or as shown directly on the CRT tube. Since this is a relative measurement, the absolute Vin or Vout voltage does not need to be determined.

Fig. 9 – Volt. vs. dB relationship



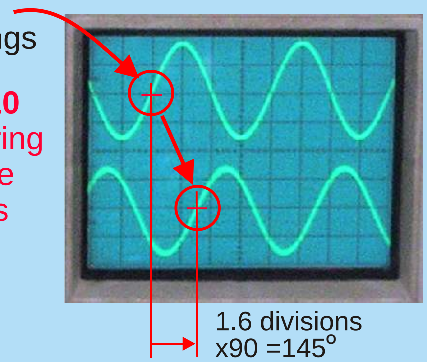


Fig. 10 Measuring Phase Shifts

Insertion Loss.

In some circuits, such as filters or attenuators, the ***loss*** in the circuit needs to be measured, and like circuit gain – expressed in dB. The loss through a circuit is called the ***insertion loss***. It is determined in the same way as amplifier gain just presented, except start with the input (the highest AC voltage) as the full-scale or reference display, then measure the output AC voltage (the lowest level). **The ratio is the insertion loss in dB.**

For example, with a signal generator connected to your receiver, you want to measure the insertion loss through the IF crystal filter. At the filter input, you can just barely squeek out 2 divisions of input signal on your scope at its most sensitive setting. The output from the crystal filter is 1.5 divisions. The insertion loss would be 20log(1.5/2.0 div.) = –2.5 dB. If the output were only 1.0 division (50% reduction), the insertion loss would be 6dB.

Fig. 11 – Phase Shift by imposition

Measuring Phase Shifts.

Phase relationships between two signals at the same frequency can be measured with 2-5° accuracy with a scope, although more suited for a dual-trace scope. The reference signal is applied to CH. 1 and the signal to be measured to CH. 2. For proper phase measurements, ensure your dual trace display is in the **chopped** mode, not **alternate** mode for proper phased referenced triggering.

There are many methods to do this. One is to stretch out the signal so it takes 4 horizontal divisions, such that each division is 90° of phase, as shown in **Fig. 10**. By measuring from a common point on one signal (zero-crossing or from peak-to-peak) to the next, the phase can be measured. For example, say you are making a phased-array antenna in which one feedline must cause a 90° delay. You calculate the electrical length for a ¼λ [L=(246/f) x Velocity Factor] and cut the coax to that length. You are now working on blind faith that you have exactly 90°. With a scope, you can measure it fairly accurately by injecting a signal into one end with a signal generator (at the frequency of interest) and a 50Ω load on the other. Connect the scope CH.1 to the coax (signal) input and CH.2 to the load end and measure the phase. In the **Fig. 10** example, the CH.2 signal is delayed by 1.6 divisions, at 90° /div is 145°. ***Your delay line is too long!*** Cut off an inch or two at a time until the CH.2 signal is 90° from CH.1 for precise tuning of the delay

line. (While departing from o-scopes for a moment, the sharp null of a phased array is astounding when exactly 90^o delay is achieved. More than $10\text{-}15^o$ in error causes a very “mushy” null with little difference over a single vertical antenna. Most errors in achieving exactly 90° by the "measure-and-cut" method are due to uncertainties in the stated velocity factor of the coax).

Another method is to superimpose the two signals on top of eachother. Make one signal larger than the other so you know which one is what, as shown in **Fig. 11**. In this example, the smaller signal lags the larger signal by about 100^o, estimated by where they cross. For more accurate determination, use the time base to measure the time period of one cycle (T1), then the time period one signal lags (or leads) the other (T2). The phase shift is then $\theta=(T2/T1)\text{x}360^o$.

Phase measurements can be made on a single trace scope as well. First, connect the reference signal, uisng a BNC "T," to both the *external trigger* and the normal *vertical input*. Adjust the trigger level so the zero-crossing occurs at the beginning of the trace (left-hand graticle). Remove the reference from the vertical input, but not the e*xternal trigger,* and apply the signal to be tested to the vertical input – without altering the time base or trigger level. The distance of zero-crossing of the test signal is from the left-hand graticle can now be measured to determine the phase, though with slightly less accuracy than using a dual-trace scope.

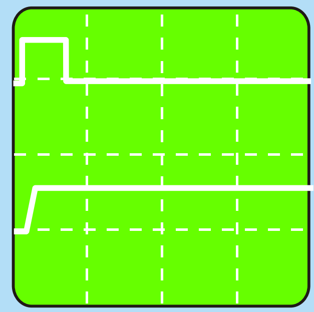
An interesting experiment is to measure the phase shift of the audio signal at different frequencies as it travels through the stages in a CW, SSB or AM active filter. What is the phase shift of the wanted vs unwanted frequencies?

Measuring Rise and Fall Times.

In digital circuits, it is sometimes important to know the rise and fall times of a signal through a gate. In amateur radio transceivers, this same interest could be applied to how fast the T-R switch switches. On key-down, if the transmitter turns on slightly before the receiver is turned off, it can produce an annoying "thump" in the receiver. Rise and fall times are measured by triggering on the edge of the signal of interest, then increase to a faster sweep speed to measure the time it takes the signal to reach 90% of its final level. The signal to be measured is shown in **Fig. 12** on the top trace, and the expanded version on the bottom. For proper rise times, the signal being measured should be well within the bandwidth of your scope and using a low capacity probe.

For example, in **Fig. 12** (bottom trace), the rise time is about 1/4th of a division. If the sweep speed is 100nS/division, the rise time would then be about 25nS.

Fig. 12 –
Rise and Fall Times



USING LIMITED BANDWIDTH SCOPES

Today's scopes have 200–500MHz bandwidths. Likely your scope is much less than that. A limited bandwidth scope is still very useful to the amateur or homebrewer. Say the bandwidth of your scope is 5MHz. This does not mean you can't see 7MHz signals. It just means the peak-to-peak value has lost meaning, and will likely be very weak, since it is beyond the bandwidth of the scope. (Like other bandwidth measurements in electronics, the “bandwidth” of a scope is usually based on the “3dB bandwidth.” That is, at the maximum bandwidth, you are already at the –3dB point, or a 25% reduction in the peak-to-peak voltage display). You can still resolve individual cycles higher than the cited bandwidth to a certain degree and make gain and phase measurements, since they are based on ***ratios.***

Most of the examples in this article explore many regions of a communications receiver or ham transceiver without the benefit of any great bandwidth. Experiment with your scope to learn its limitations. ***Use a good scope probe and make measurements with a good ground to get the most out of the bandwidth you have.***

For the homebrewer building circuits in the HF bands, a 50 MHz scope **with good calibration** will yield fairly accurate measurements up to 30 MHz with little concern for accuracy. The old 465 or 475 series of Tektronix scopes, with 100/200 MHz bandwidths, make an excellent oscilloscope for the amateur or experimenter. They can often be found at hamfests today for $100–150, and tend to maintain a fairly good calibration almost regardless of how much use they have seen.

In Part 2 - we'll probe (bad pun) into some advanced measurement techniques, even with a simple scope ... such as measuring sideband rejection, filter responses, VCO phase noise, etc. (and what it all means).

72, Paul NA5N

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pharden@nrao.edu

Colophon:
Article prepared by NA5N using CorelDraw 11

THE HANDYMAN'S GUIDE TO OSCILLOSCOPES (Part 1 of 2)

by Paul Harden, NA5N

Print as .pdf file
5 pages
8½ x 11 or A4

Getting Acquainted with your Scope and making some measurements

Updated May 2004 *with actual oscope waveforms*

When in the course of human events, it becomes necessary to look at neat signals floating around your radio, you go to a hamfest and buy that $50 o-scope. Now what? This two part article will attempt to explain basically how an oscilloscope works, operator functions, basic measurements, and some advanced applications. An o-scope is a powerful tool in any shack – even a real "cheapie" with limited bandwidth.

HOW AN OSCILLOSCOPE WORKS

A block diagram of a typical o-scope is shown in **Fig. 1**. The test probe usually plugs into the scope via a BNC connector, then passes through a switch to determine whether the input signal will be dc or ac coupled (to remove any dc component). Often this switch will have a "ground" position for setting the zero-volts reference. Next is the input attenuators. The vertical input amplifier is quite sensitive, designed for 20-50mV of input. For larger input voltages, the signal is applied to attenuators comprised of simple voltage dividers. This is the first area of concern for cheap o-scopes, as the input attenuators may not be very linear or accurate. For example, if you appy a 10Vpp signal on the 10v/division setting, the signal should be 1 division high. Switching to 1v/div., the signal should be 10 divisions (usually full-scale) high. If it is not exactly 10 divisions, the attenuator for that setting needs adjusting. Some scopes have internal adjustments for fine-tuning each attenuator setting.

Following the attenuators, the signal is applied to the first vertical amplifier, which converts the input to a differential signal. This differential signal is amplified up to high voltages for the oscilloscope deflecting plates – moving the beam up and down (in the vertical axis).

The sweep generator is usually a constant current source charging a capacitor to make a sawtooth waveform that eventually deflects the beam in the horizontal axis. The frequency of the sawtooth determines how fast the beam travels from the left to the right side of the tube, and is controlled by the sweep control, usually calibrated in seconds, milli-seconds or micro-seconds per division. This is the second area of concern for an oscilloscope – how linear the sawtooth waveform is generated. For example, a sawtooth with a nonlinear ramp will cause the signal displayed in the central portion of the tube to be expanded or compressed compared to the signal at the ends.

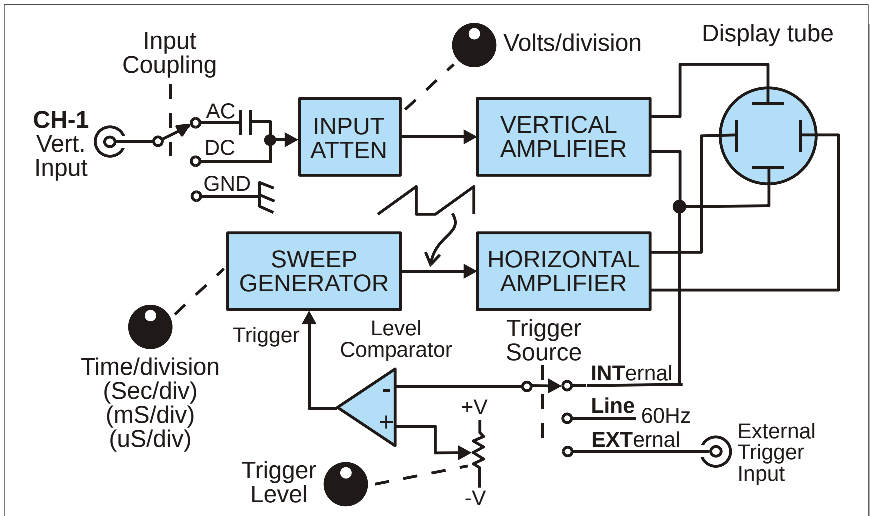

FIG. 1 - Basic block diagram of an Oscilloscpe

The sawtooth ramp is amplified to high voltages, applied to the oscope tube, to deflect the beam from left to right. An important task of an oscope is when the horizontal deflection begins. Normally a switch labeled "Trigger Source" determines what initiates the sawtooth ramp. In the "Internal" position, a sample of the input signal (in the vertical amplifiers) is sampled, with a variable resistor setting the level. When the input signal exceeds the "Trigger Level," a pulse is generated to start the sawtooth ramp and hence the horizontal sweep. The purpose of triggering is to keep the input waveform synchronized to the sweep so it appears stationary on each sweep. The trigger source usually has a "Line" position, which simply triggers the sweep off of 60Hz from the power supply. This synchronizes the sweep to the AC power frequency and is useful for checking television signals, which are synchronized to the power mains. Also, an "External" position may be present, which connects an external input signal (via a BNC connector) to trigger the sweep generator.

Other features your oscope may have are two vertical channels for dual trace operation, various modes to display both waveforms (alternate, chopped, A+B added, etc.), delayed sweep features, dual sweep time bases, built in calibrators, etc.

CALIBRATING YOUR OSCILLOSCOPE

The first thing you should do upon acquiring an o-scope is to check its calibration.

The vertical amplfiers can be checked with a known voltage source or 9v transistor radio battery. Measure the output voltage of the battery with an accurate voltmeter. Let's say it just happens to be +9v exactly. Set the input coupling to ground (0v) and move the trace to the bottom division. Switch the input coupling to DC and set the attenuators to 1v/div. The deflection should be 9

divisions. Switching to 10v/div., deflection should be 0.9 divisions. Internal to the oscope (or perhaps accessible from the outside) are adjustments for the vertical amplifier gain. Adjust this for 9 divisions of deflection in the 1v/div. range. Procedure can be repeated with a 1.5v flashlight battery (assuming you know the exact voltage from a DVM).

The horizontal amplifiers should be checked/calibrated using a signal generator. For example, a 1MHz signal has a period of 1uS. Setting the sweep rate to 1.0uS/div., a 1MHz signal should take exactly 1 division per cycle. Set the horizontal width control properly to ensure the beam starts at the first division and ends at the last division. If the sweep rate appears incorrect, an internal adjustment (Sweep gain or similar) can be set for proper display of the test signal.

The main operator controls are:
- **Intensity** - controls the brightness of the beam. **NOTE: Too bright a beam can damage to the CRT tube!**
- **Focus** - adjusts the beam for the thinnest and sharpest display.
- **VERT & HOR Position** - controls the vertical and horizontal position of the display respectively
- **VERT V/div** - controls the vertical sensitivity of the display, i.e., how many volts (or mV) per division.
- **HOR Sweep Speed** - sets the horizontal sensitivity, i.e., how many mS or uS per division.
- **VERT & HOR vernier** - allows the vertical and horizontal sensitivity settings to be varied in small steps.

Other adjustments you may find on your scope are:

Astigmatism - With the scope intensity and focus properly set, this adjustment compensates for the curvature of the CRT tube by making it in-focus across the sweep. If your trace is out-of-focus in certain areas, but in-focus elsewhere, the astigmatism needs to be adjusted. See ***Fig. 2***.

Trace Rotation - is a small coil around the CRT that skews the trace to ensure it is perfectly horizontal. On scopes without this adjustment, the trace is leveled by physically rotating the CRT to align the trace to the graticle grid. See ***Fig. 2***.

DC BAL (DC Balance) - is a dc offset in the vertical amplifiers that causes a shift in the trace baseline when changing vertical scales. It is most obvious when measuring ac voltages. For example, you are displaying a 10Vpp sine wave, centered on the center graticle, at 2v/div. Changing to 5v/div, the sine wave shifts off the center graticle ... that is, it assumes a dc bias error. The DC BAL is adjusted until the shift no longer occurs when changing vertical scales.

HV ADJ. - is the high voltage that controls the intensity of the trace. Turn up the **Intensity** control to its brightest position, then adjust the HV ADJ for a trace slightly brighter than normal intensity. The **Intensity** control now has the proper range. The HV ADJ might have to be re-adjusted to acquire proper focus.

NOTE: Very bright trace displays can cause permanent damage to the CRT, particularly on a well-used scope.

Fig. 2 – Effects of Astigmatism & Trace Rotation

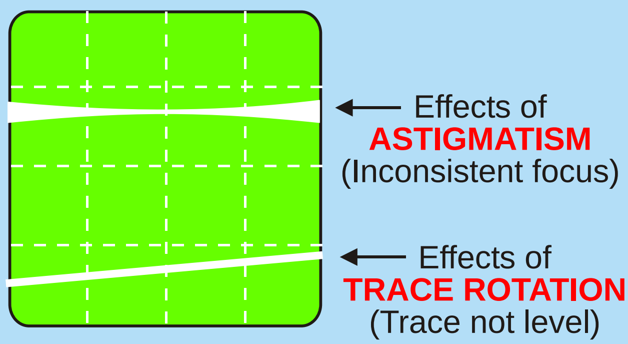

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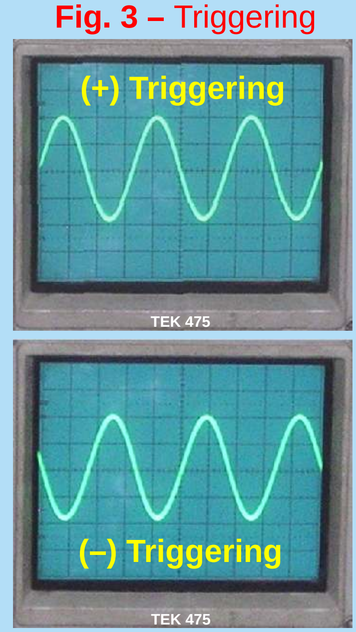
Fig. 3 – Triggering



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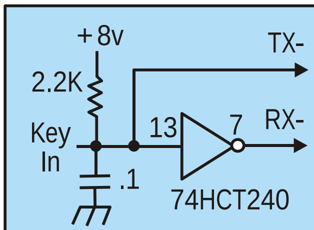
Place the scope lead on pin 13 at 10v/div. and you should see the waveform like the top trace in ***Fig. 4*** ... about +6v on key-up and 0v on key down. Move the scope lead to pin 7 and you should see 0v on key-up and about +8v on key-down (bottom trace). If the output does not go "HI" (+8v) on key-down, or does not go to a solid "LO" (<1v) on key-up, the inverter is not working properly. (It's busticated). Many shortwave receivers use similar schemes for switching filters or attenuators.

While this test could be done with a DVM, the integration time is slow, requiring long key-downs to get the voltages. A scope will also show you how clean the switching is, or if there is an ac voltage (or RF noise) riding on the T-R voltage.

Scopes are thus good dc voltmeters, with about a 5% reading accuracy.



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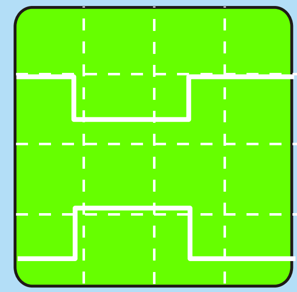

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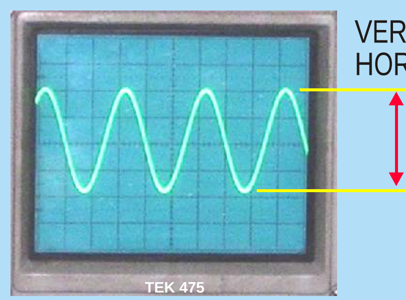


VERT: 0.5v/div ACV
HOR: 0.5mS/div

3.8 divisions peak-to-peak times 0.5v/div
= 1.9 Vpp
= 0.67 Vrms

Fig. 5

AC Frequency Measurement.

With this waveform, we might as well see what frequency our sidetone or transmit-offset frequency is. Most operators prefer the sidetone to be about 700–750Hz. Trigger the scope for a stable waveform and set the time-base (sweep) to display 2 or 3 cycles, as shown in ***Fig. 6***. Center the waveform between two horizontal divisions so zero volts on the waveform is on a graticule line, then move the horizontal position so the first "zero– crossing" is also on a division line.

Measure the time it takes to make one complete sine wave from one zero-crossing to the next. In this example, it is 1.5 divisions, at 1mS per division, or 1.5mS. Frequency is simply the reciprocal of time, such that the sidetone frequency is:

$$f = \frac{1}{t} = \frac{1}{1.5\text{mS}} = 667\text{ Hz}$$

For some, this may be about right. For others, this may be a little low to your liking. To raise it to 700Hz, calculate the time period of 700Hz (1/700 = 1.4mS). At 1.0mS/div, you can adjust your sidetone or transmit offset until zero-crossings for a single sinewave is 1.4 divisions. This will be about 700 Hz. (Sidetone may not be adjustable on some rigs).

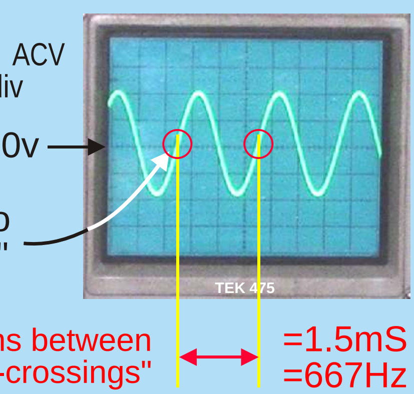
All frequency measurements are made in this fashion, by measuring the distance between zero-crossings (or from one peak to the next) and converting the time period to frequency. This should emphasize the importance of ensuring your sweep speed is calibrated; as any error in the time base will cause a corresponding error in the accuracy of your time or frequency measurements.

Fig. 6

VERT: 0.5v/div ACV
HOR: 0.5mS/div

0v

First "Zero Crossing"



3 divisions between "zero-crossings"
=1.5mS
=667Hz

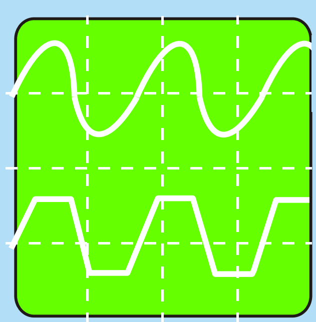


Fig. 7

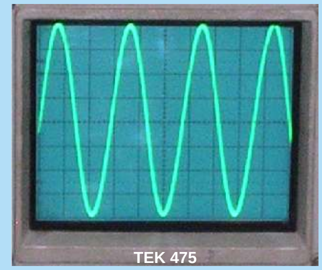
Example of Waveform Quality

VERT: 2v/div ACV
HOR: 1.0mS/div

Quality of the waveform is another feature of a scope that is unsurpassed since you are "seeing" the waveform in real time. Two examples of waveform quality are shown in ***Fig. 7***.

The top trace shows the sidetone frequency with distortion, perhaps due to improper time-constant on the coupling capacitors or improperly biased audio amplifiers. The bottom trace would be a raspy sounding side tone, due to the amplifier being over-driven and in compression (clipping). The o-scope is an invaluable tool for detecting and diagnosing such impurities in the signal quality.

FIG. 8 – Full Scale Signal Display



Actual display Tektronix 475

MORE NIFTY MEASUREMENTS

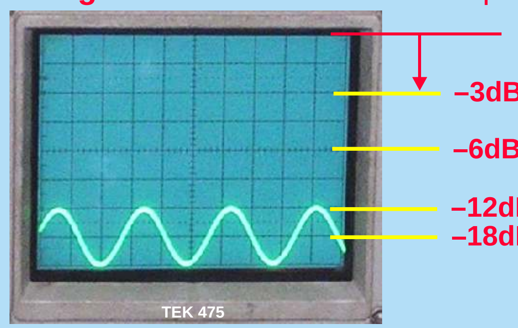
Amplifier Gain.

The gain of an amplifier can be measured in terms of voltage or decibels (dB). For voltage gain, it is simply Vout/Vin of the amplifier. For example, if the input is 1Vpp and the output is 4Vpp, then the amplifier has a voltage gain of 4.

Gain in dB is often more useful and is how the gains of amplifiers are usually expressed. With dB's, every-time you double the AC voltage, you add 6dB of gain. It is the **ratio** of output to the input, and this **ratio** is easy to measure on a scope.

It is often easier to start with the output. Set the vertical amplifier gain to display the amplifier **output** as a full-scale signal as shown in ***Fig. 8***. Now move the scope probe to the amplifier **input** without disturbing the scope gain. You will of course have a much smaller signal, and the ratio of the input to the output will be the gain in dB. In our example of using eight divisions for full-scale, then four divisions would be 6db, 2 divisions 12dB, etc. as shown in **Fig. 9.** You may want to add your own dB scale along your scope display to remind you of this relationship. Note: this is ***voltage gain*** (Av=20log x Vout/Vin). In this example, with 4Vpp output and 1Vpp input (Av=4), then the gain is dB=20log(4) = 20(0.602) = 12dB, or as shown directly on the CRT tube. Since this is a relative measurement, the absolute Vin or Vout voltage does not need to be determined.

Fig. 9 – Volt. vs. dB relationship



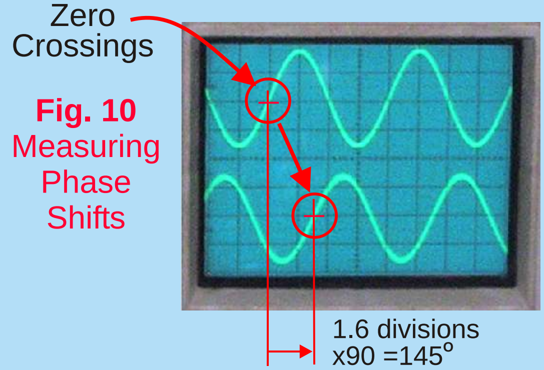


Fig. 10 Measuring Phase Shifts

Insertion Loss.

In some circuits, such as filters or attenuators, the ***loss*** in the circuit needs to be measured, and like circuit gain – expressed in dB. The loss through a circuit is called the ***insertion loss.*** It is determined in the same way as amplifier gain just presented, except start with the input (the highest AC voltage) as the full-scale or reference display, then measure the output AC voltage (the lowest level). **The ratio is the insertion loss in dB.**

For example, with a signal generator connected to your receiver, you want to measure the insertion loss through the IF crystal filter. At the filter input, you can just barely squeek out 2 divisions of input signal on your scope at its most sensitive setting. The output from the crystal filter is 1.5 divisions. The insertion loss would be 20log(1.5/2.0 div.) = –2.5 dB. If the output were only 1.0 division (50% reduction), the insertion loss would be 6dB.

Fig. 11 – Phase Shift by imposition

Measuring Phase Shifts.

Phase relationships between two signals at the same frequency can be measured with 2-5° accuracy with a scope, although more suited for a dual-trace scope. The reference signal is applied to CH. 1 and the signal to be measured to CH. 2. For proper phase measurements, ensure your dual trace display is in the **chopped** mode, not **alternate** mode for proper phased referenced triggering.

There are many methods to do this. One is to stretch out the signal so it takes 4 horizontal divisions, such that each division is 90° of phase, as shown in **Fig. 10**. By measuring from a common point on one signal (zero-crossing or from peak-to-peak) to the next, the phase can be measured. For example, say you are making a phased-array antenna in which one feedline must cause a 90° delay. You calculate the electrical length for a ¼λ [L=(246/f) x Velocity Factor] and cut the coax to that length. You are now working on blind faith that you have exactly 90°. With a scope, you can measure it fairly accurately by injecting a signal into one end with a signal generator (at the frequency of interest) and a 50Ω load on the other. Connect the scope CH.1 to the coax (signal) input and CH.2 to the load end and measure the phase. In the **Fig. 10** example, the CH.2 signal is delayed by 1.6 divisions, at 90° /div is 145°. ***Your delay line is too long!*** Cut off an inch or two at a time until the CH.2 signal is 90° from CH.1 for precise tuning of the delay

line. (While departing from o-scopes for a moment, the sharp null of a phased array is astounding when exactly 90° delay is achieved. More than 10-15° in error causes a very "mushy" null with little difference over a single vertical antenna. Most errors in achieving exactly 90° by the "measure-and-cut" method are due to uncertainties in the stated velocity factor of the coax).

Another method is to superimpose the two signals on top of eachother. Make one signal larger than the other so you know which one is what, as shown in **Fig. 11**. In this example, the smaller signal lags the larger signal by about 100°, estimated by where they cross. For more accurate determination, use the time base to measure the time period of one cycle (T1), then the time period one signal lags (or leads) the other (T2). The phase shift is then $\theta = (T2/T1) \times 360^{o}$.

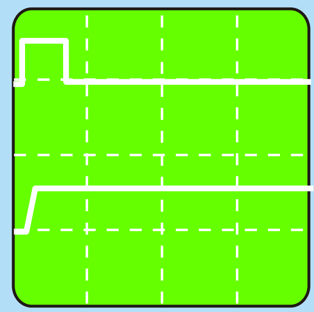
Phase measurements can be made on a single trace scope as well. First, connect the reference signal, uisng a BNC "T," to both the *external trigger* and the normal *vertical input*. Adjust the trigger level so the zero-crossing occurs at the beginning of the trace (left-hand graticle). Remove the reference from the vertical input, but not the e*xternal trigger,* and apply the signal to be tested to the vertical input – without altering the time base or trigger level. The distance of zero-crossing of the test signal is from the left-hand graticle can now be measured to determine the phase, though with slightly less accuracy than using a dual-trace scope.

An interesting experiment is to measure the phase shift of the audio signal at different frequencies as it travels through the stages in a CW, SSB or AM active filter. What is the phase shift of the wanted vs unwanted frequencies?

Measuring Rise and Fall Times.

In digital circuits, it is sometimes important to know the rise and fall times of a signal through a gate. In amateur radio transceivers, this same interest could be applied to how fast the T-R switch switches. On key-down, if the transmitter turns on slightly before the receiver is turned off, it can produce an annoying "thump" in the receiver. Rise and fall times are measured by triggering on the edge of the signal of interest, then increase to a faster sweep speed to measure the time it takes the signal to reach 90% of its final level. The signal to be measured is shown in **Fig. 12** on the top trace, and the expanded version on the bottom. For proper rise times, the signal being measured should be well within the bandwidth of your scope and using a low capacity probe.

Fig. 12 –
Rise and Fall Times



For example, in **Fig. 12** (bottom trace), the rise time is about 1/4th of a division. If the sweep speed is 100nS/division, the rise time would then be about 25nS.

USING LIMITED BANDWIDTH SCOPES

Today's scopes have 200–500MHz bandwidths. Likely your scope is much less than that. A limited bandwidth scope is still very useful to the amateur or homebrewer. Say the bandwidth of your scope is 5MHz. This does not mean you can't see 7MHz signals. It just means the peak-to-peak value has lost meaning, and will likely be very weak, since it is beyond the bandwidth of the scope. (Like other bandwidth measurements in electronics, the "bandwidth" of a scope is usually based on the "3dB bandwidth." That is, at the maximum bandwidth, you are already at the –3dB point, or a 25% reduction in the peak-to-peak voltage display). You can still resolve individual cycles higher than the cited bandwidth to a certain degree and make gain and phase measurements, since they are based on ***ratios.***

Most of the examples in this article explore many regions of a communications receiver or ham transceiver without the benefit of any great bandwidth. Experiment with your scope to learn its limitations. ***Use a good scope probe and make measurements with a good ground to get the most out of the bandwidth you have.***

For the homebrewer building circuits in the HF bands, a 50 MHz scope **with good calibration** will yield fairly accurate measurements up to 30 MHz with little concern for accuracy. The old 465 or 475 series of Tektronix scopes, with 100/200 MHz bandwidths, make an excellent oscilloscope for the amateur or experimenter. They can often be found at hamfests today for $100–150, and tend to maintain a fairly good calibration almost regardless of how much use they have seen.

In Part 2 - we'll probe (bad pun) into some advanced measurement techniques, even with a simple scope ... such as measuring sideband rejection, filter responses, VCO phase noise, etc. (and what it all means).

72, Paul NA5N

na5n@zianet.com
pharden@nrao.edu

Colophon:
Article prepared by NA5N using CorelDraw 11

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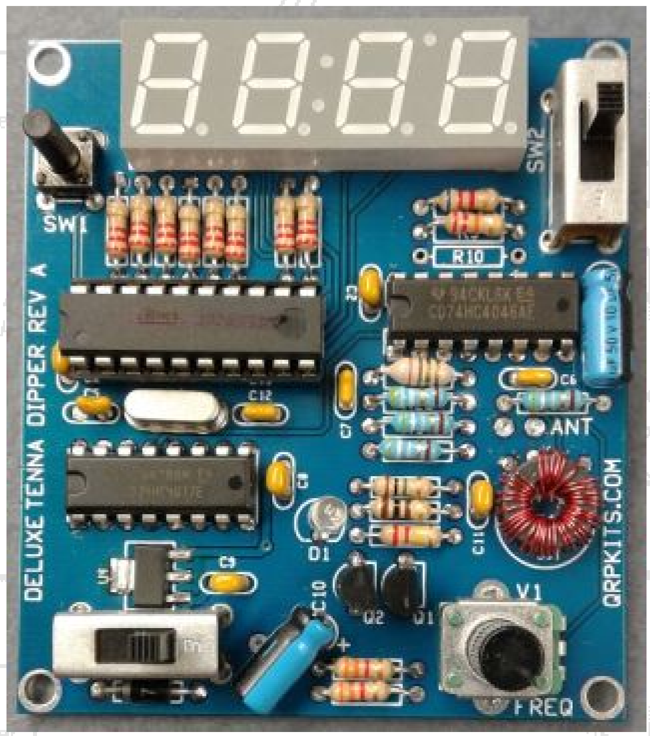
Deluxe Tenna Dipper Board and Parts Kit

Designed by Steve Weber, KD1JV



The Deluxe Tenna Dipper provides a simple means of determining the 50 ohm resonant frequency of an HF antenna or ATU (Antenna Tuning Unit). The small size and battery operation makes the unit ideal for use in the field. It's perfect for antenna experimenters that don't want to tie a bunch of money up in the higher priced analyzers. It's even priced lower than most swr bridges, and this tells you "where" you are resonant, not just that it's matched, or not matched, like a simple swr bridge.

Features:

- Wide tuning range: ~3 MHz to ~30 MHz in two ranges
- Four digit digital display with display shift down to 100Hz
- Eliminates the need for a transmitter and SWR bridge when:
- Trimming length of resonate dipole, and portable vertical antennas
- QRM free adjusting of antenna tuners and antennas
- Quickly adjust short, portable vertical antennas, eg. PAC-12 & Screwdriver antennas, etc.

- Current draw is approximately 50mA
- Weight w/batteries: .66 lbs./10.6 oz./ 300g

How it Works:

A voltage controlled R/C oscillator generates a 5 volt square wave signal. This signal drives a resistive Wheatstone bridge. One leg of the bridge is the "unknown" resistance, the antenna. A wide band step up transformer is connected across the bridge to detect the signal produced when the bridge is unbalanced. This signal is farther amplified by a Darlington pair transistor amplifier. A high brightness LED is used to visually indicate the current in the collector of the amplifier. When the antenna impedance at the unknown leg of the bridge is equal to 50 ohms, the bridge is in balance and the LED will go out. Hence the name for this device, the Tenna Dipper, as we dip the brightness of the LED to find the 50 ohm match.

Supporting Files and Documents

Deluxe Tenna Dipper Manual (10/30/2017)

Subscribe to the DeluxeTennaDipper group

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YAHOO! Groups Join Now!

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Deluxe Tenna Dipper (Board and parts kit)): $50.00 Add

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Michigan Mighty Mite's

Experience the joy of oscillation!

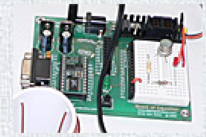
2N2219A

This little pearl have been used in each of our Michigan Mighty Mites transmitters.

Old classic crystal, model FT-243 with a modern crystal embedded, a HC-18 crystal

There is not complete agreement on what constitutes QRP power. While most QRP enthusiasts agree that for CW; AM; FM; and data modes, the transmitter output power should be 5 watts (or less), the maximum output power for SSB (single sideband) is not always agreed upon. Some believe that the power should be no more than 10 watts peak envelope power (PEP), while others strongly hold that the power limit should be 5 watts. QRPers are known to use even less than five watts, sometimes operating with as little as 100 milliwatts or even less. Extremely low power,1 watt and below, is often referred to by hobbyists as QRPP.

Some links to Michigan Mighty Mite transmitters...



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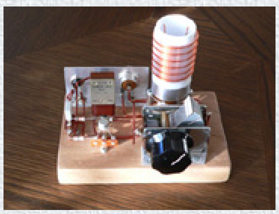

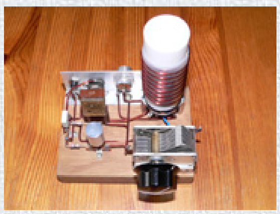

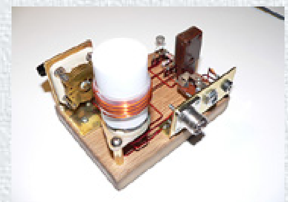

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Dual Band 20m and 40m Trap Dipole Antenna

Parts included in kit

Assembled Dipole

Coil Forms

Description

The Pacific Antenna Dual Band Dipole kit is a lightweight, portable trap dipole.

- Covers both 20 and 40M and handles power up to 100W of RF.

- Includes everything necessary for assembly.
- Weighs approximately 4 ounces.
- Length is approximately 48ft.
- Can be configured as a dipole, inverted V or upright V antenna configuration.
- Ideal for travel, backpacking, emergency, ARES/RACES, and SOTA operation.

Supporting Files and Documents

Dual Band 20m and 40m Trap Dipole Antenna (9/22/2017)

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Dual Band 20m 40m Trap Dipole: 25.00 — Add

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Loop-Stick Crystal Set

Dan McGillis

Mon Jan 26, 2009 12:52 pm

Hi all.

I used this little loop-stick radio in the just-ended ‘09 Crystal Radio DX contest. Wanted to see how it would do as a simple double-tuned rig.

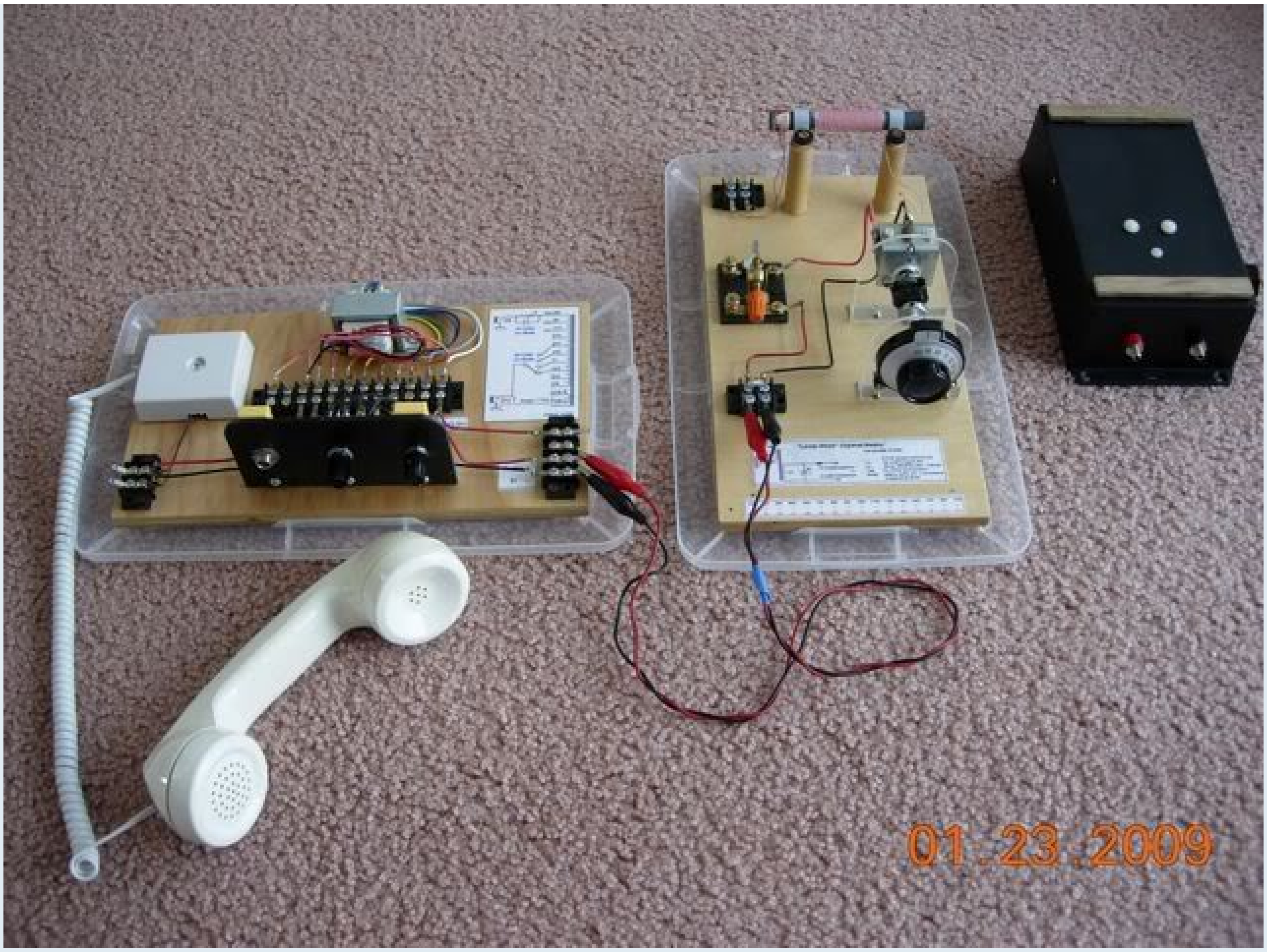
Not too bad: 84 stations ID’d in about 13 hrs of listening time.
-------A big old 200’ antenna certainly helps a bit

This setup makes a nice progressive radio for the grandkids (& grandpa):

- start out with the basic cat’s whisker detector (thanks Mike),
- add a good FO-215 diode,
- add a Bogen+Benny for some audio matching,
- add an antenna tuner,

and you wind up with a decent little set.

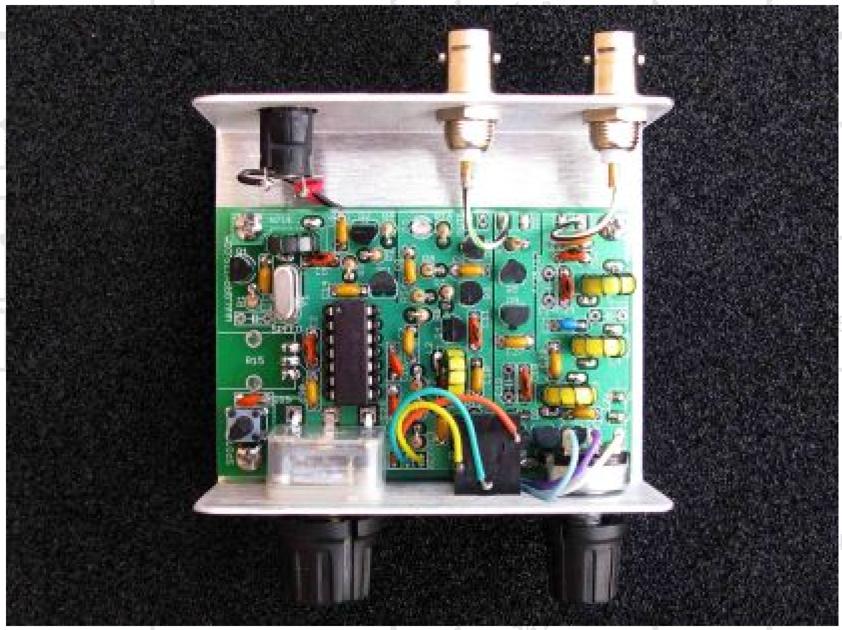
Here’s a picture.



Fun stuff.

73, Dan

Simple Transmitter (TST)



Specifications

- Power Output: ~4w into a 50 ohm load at 12v
- TX power amplifier efficiency: ~70%. Finals stays cooler, transmitter draws less power. Note: TX designed for CW type transmit duty cycle. Prolonged key down operation is not advised.
- TX harmonic output suppression readily exceeds FCC specifications: >55 dB attenuation typical
- Spot Switch: Turns on the oscillator and buffer so that you can find it with a receiver
- Built In Keyer: Keyer chip included with adjustable cw speed pot
- Straight Key mode: Power up with the jack "ring" shorted (mono plug) causes the keyer to enter
- straight key mode. This mode is useful with external memory keyers for beacon use, as well as normal straight keys or bugs.
- Straight Key "dotting" mode: Staying key down for several seconds places the transmitter into "dotting" to protect the finals.
- Built in receiver T/R switch with "mute" output: An external receiver can be hooked up directly to the transmitter "RX" output. "Mute" output provides an open collector shunt to ground during transmit.

Supporting Files and Documents

Simple Transmitter Assembly Manual (9/1/2015 update)

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Simple Transmitter 10M (TST): 60.00 — Add

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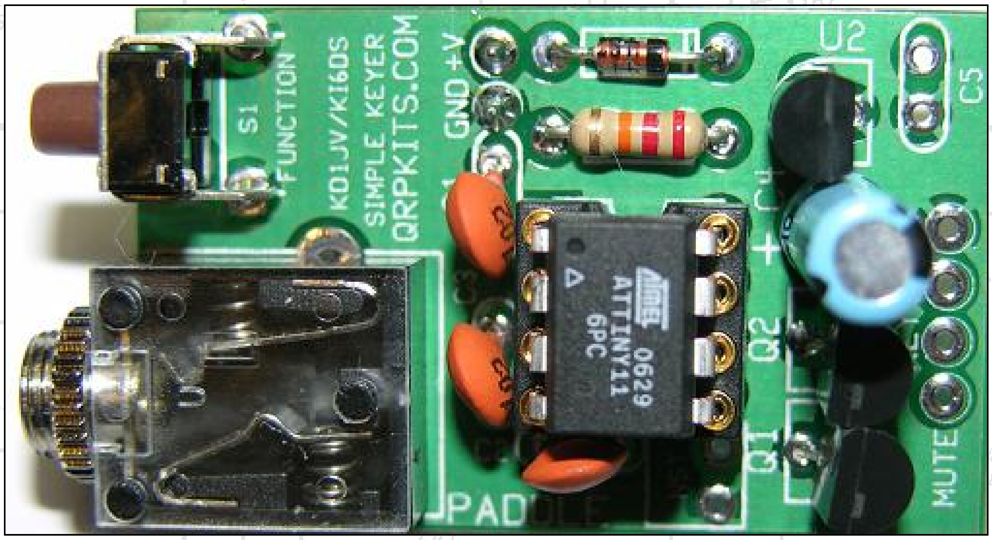
Simple Keyer Chip Keyer Kit



Features

- Speed range of 5 to 30 wpm
- Operates in either iambic A or B mode, with B being the default
- 2 message memories of 29 characters each
- Tune and Beacon modes
- Built on a 1 inch by 1.5 inch circuit board
- If panel mounted, only two holes needed

Manuals and other useful information

[Simple Keyer Chip Keyer Builders Manual (4/21/2017)]

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Simple Keyer Chip Keyer: $15.00 Add

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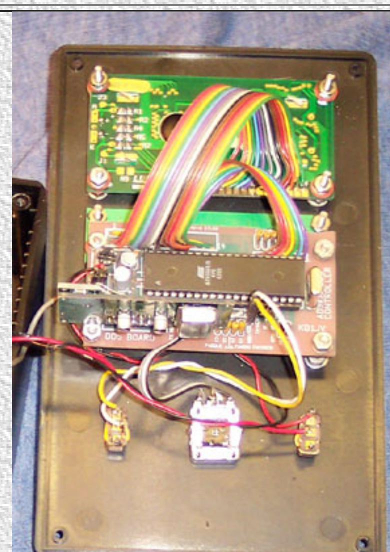
KD1JV's DDS Controler

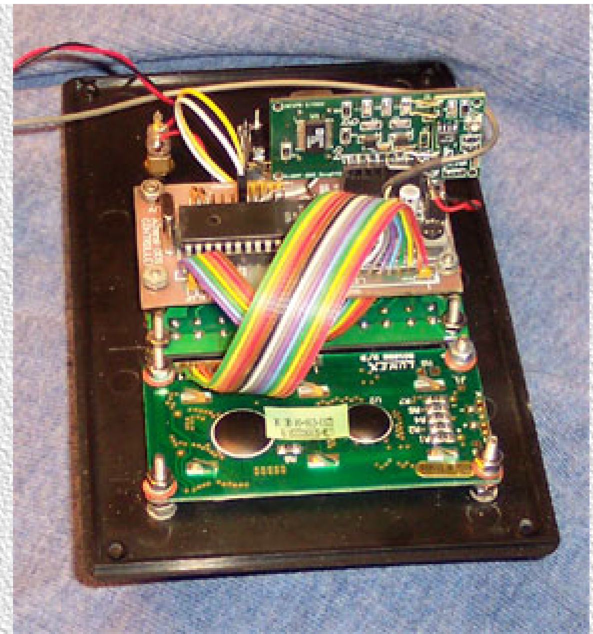
I Built this DDS control for the AD9850 American QRP Club's DDS card to be a VFO for some of my receiver and transmitter projects. It is such a really neat application to get a really stable, reliable, frequency accurate VFO. The unit worked flawlessly but I had trouble finding a suitable enclosure. So I operated it "Bare Board" for quite a while. I finally found a plastic box in which to mount my DDS VFO and Controller in a manner where it was easy to operate and connect to any project where I would need it. The picture at left is the fruits of my labors. I still have to do the switch marking . I did add a switch so that I could use it as both a signal generator or a VFO.

Since I only wanted the DDS VFO or the Signal Generator function, I did not do any of the hook ups for the built in CW keyer or the antenna switching functions that are also in the software for this unit. I may want to use them later and there is still room on the side panels to put in the necessary connectors for thos functions. I installed all of the boards for the controller on the top or lid of the box and let them hang down inside. I did use one of the new AMQRP shaft encoders because I liked the detentless operation. It just seemed smoother to me.



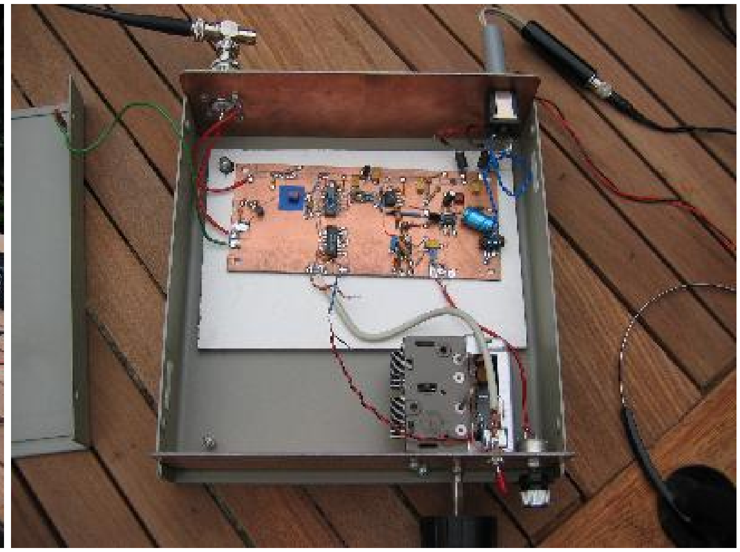
I used the famos long 4 X 40 screw technique to be able to adjust the boards in elevation to the box so everything would fit smoothly. The AD9850 DDS card with it's new output amplifier can be seen in the upper right hand side of the picture. the lower front is the backlighted LCD display, followed by the Switch board with the DDS Controller board mounted over the Switch card. The coax output and the power input connectors are mounted on the side of the plastic box. It is really a clean and neat unit and so nice to use.

I have heard that KD1JV has a new kit out for the newer DDS-60 60Mhz DDS card. I already have one on order and will be adding it to this page as soon as I get it built.

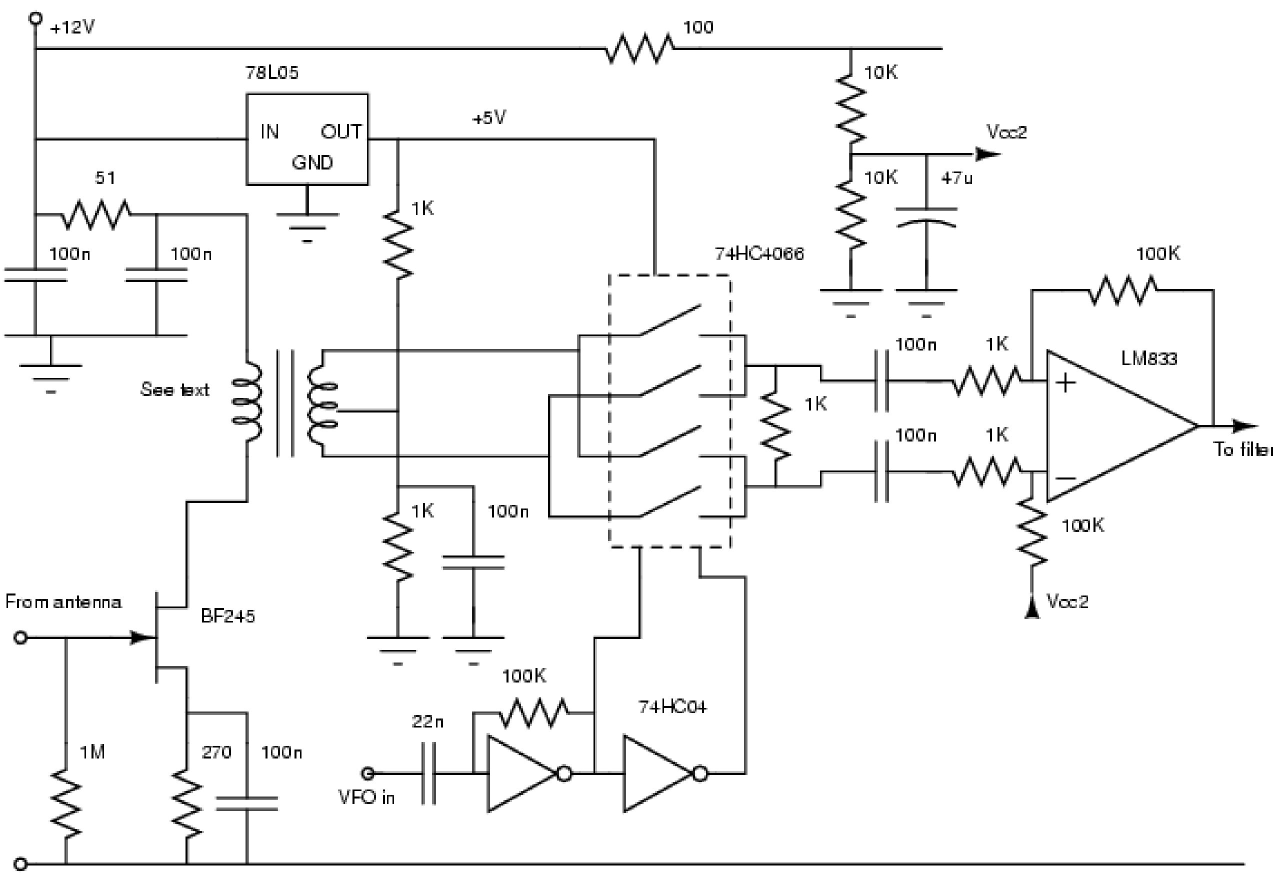


[back to Dave's Ham Radio Projects page](http://www.zianet.com/dhassall/)

Direct Conversion receiver for 80m and 40m

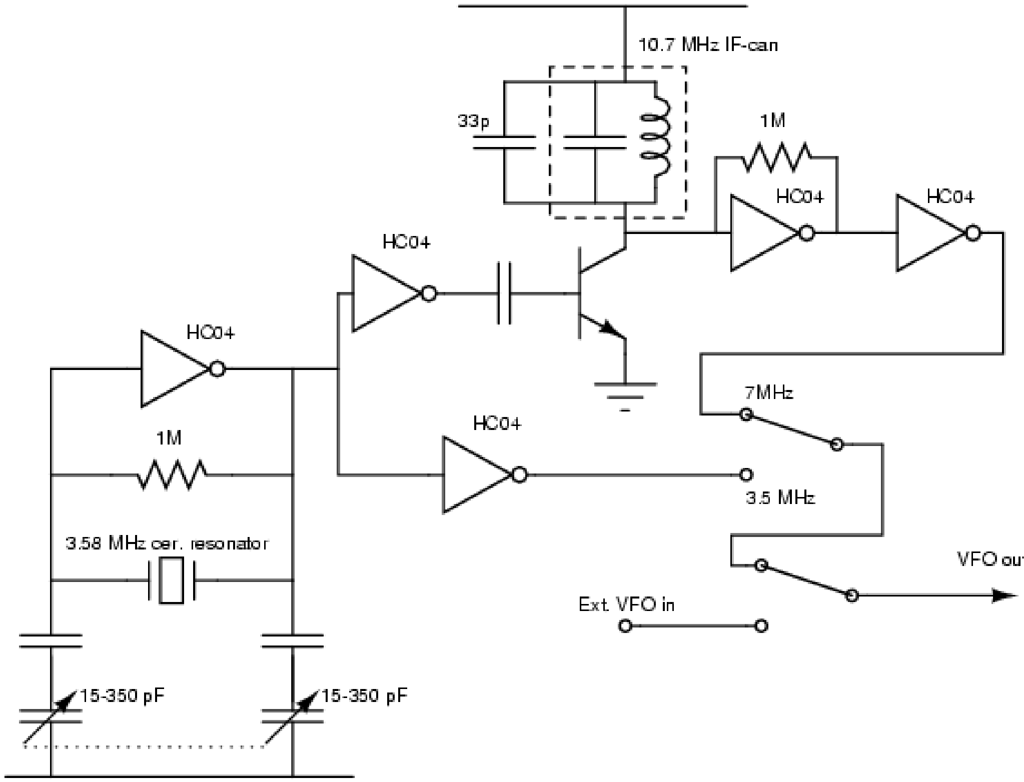
	
Receiver front view	Receiver internals

The design for this receiver is from [Steve KD1JV](). Some changes have been made to the KD1JV design.



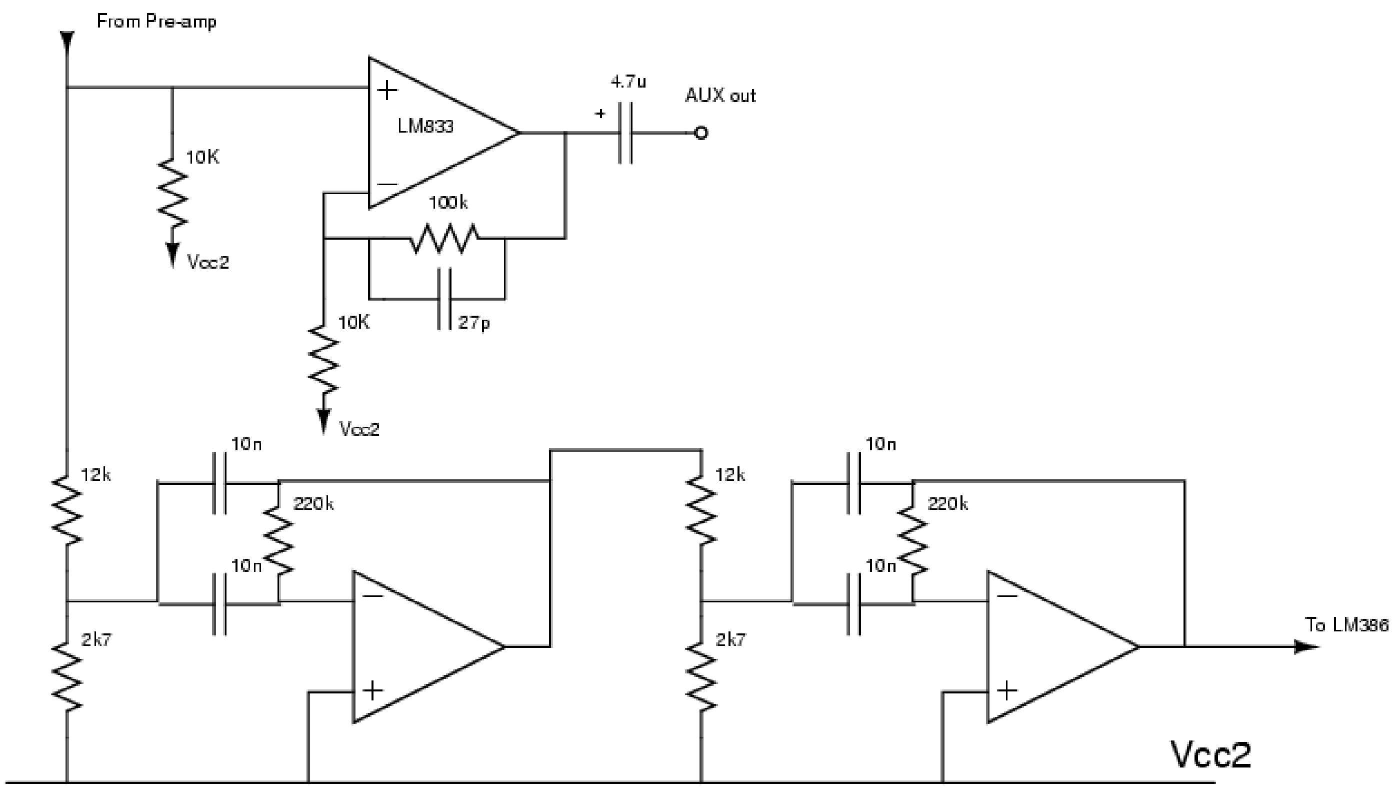
Pre-amplifier, mixer and first amplifier.

I used a 74HC4066 quad switch and a 74HC04 inverter, because the junkbox did not contain a 74HC4053 at the time of building. The original BN-43-2402 binocular core has an Al value of 1275 nH/turn2. With 6 turns the primary has an inductance of 45.9 uH. If another core is used the turns count should be adjusted to get the same inductance. The secondary turns count has to be adjusted with the same factor. I used a FT50-43 with 10 turns on the primary and 2x3 turns on the secondary.



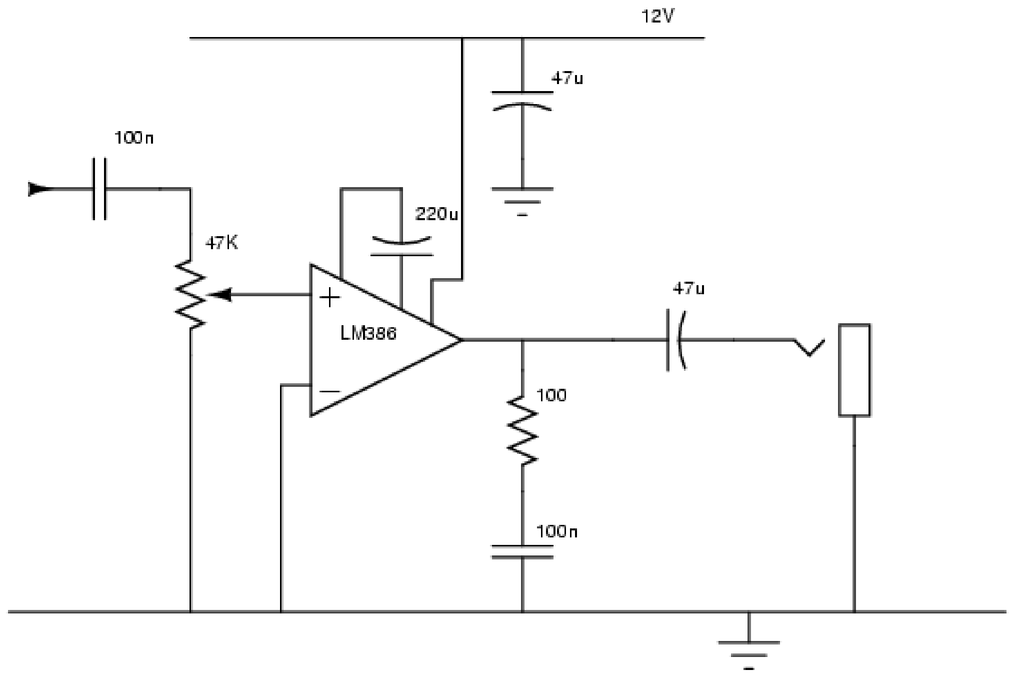
VFO with ceramic resonator.

Experiment with the variable capacitor and both series capacitors to get the band coverage you want.



700 Hz filter and auxilary output.

The main purpose of this reciever is to get coverage of the CW segment of the 40m band. For experimental purposes I added the auxilary output and an external VFO input.



AF amplifier.

Nothing fancy here, straight from the datasheet.


Receiver with loop antenna

The receiver does not have any form of pre-selection. I use a loop antenna. It's not perfect, but it works.

[Archive](#) containing the Xcircuit files (encapsulated postscript).

References:

- [DC RECEIVER DESIGN NOTES and PROBLEM CURES](#) .

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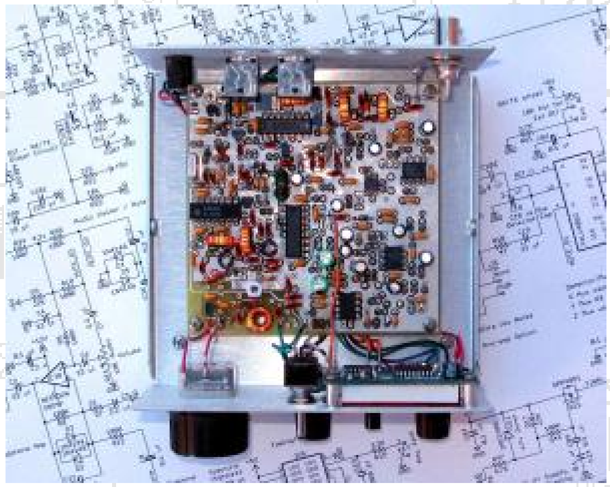
Affordable QRP Antennas and Kits at exceptional value

Ft Tuthill 15m or 160m CW Transceiver



Shown with optional Digital Dial

Specifications

Receiver:

- DC receiver (not a superhet)
- Current Drain: Approximately 45 ma @ 12v. The addition of the counter adds ~ 22 ma of addition current drain.
- Supply voltage range: 10.5 to 14v
- Receiver bandwidth: 700 Hz. Five pole R/C active filter provides the selectivity, nominally 3 dB down at 1 KHz, 40 dB down at ~2 KHz, 100 dB down at ~ 8 KHz
- 0.16 uV receiver sensitivity
- 5v pk-pk receiver detector design enables stout large signal performance

Transmitter:

- Power Output ~ 5w at 12v , 760 mA
- All output harmonics less than -50 dBc
- Transmitter is set up for a straight key input

Features:

- Both RIT and XIT are provided with ~ ± 4000 Hz tuning range.
- 60 KHz tuning ranges for 15m, ~ 21.000 - 21.060 and 21.075 - 21.135 MHz, or are available using a front panel range switch.

- 30 KHz tuning ranges for 160m, ~ 1800 - 1835 and 1830 - 1865 MHz, or are available using a front panel range switch.
- Spot switch to allow setting precise TX spotting. Spotting mode is entered via a push button. A 800 Hz blip is sent once a second to remind the user that the rig is in the "spot" mode.
- Transmit protection - When the transmitter is left key down for more than three seconds, the transmitter going into a "dotting" mode. The transmitter is capable of running indefinitely in dotting mode.
- The audio output has been designed to drive headphones and have been provided with audio compression to protect the user from sudden, large signals when using headphones.
- A regulated 5v output has been provided for external keyer kits.

Supporting Files and Documents

Ft Tuthill 15m Assembly/Operation Manual - Part 1 (v6)

Ft Tuthill 15m Assembly/Operation Manual - Part 2 (v5)

Revised Assembly instructions for the Bail

Ft Tuthill 15m Schematic

Ft Tuthill 160 Assembly/Operation Manual - Part 1

Ft Tuthill 160 Assembly/Operation Manual - Part 2

Ft Tuthill 160 Schematic

Ft Tuthill 160 Parts Overlays

Ft Tuthill Decal Instruction Manual

Ft Tuthill Chassis Preparation Manual

Links for 160m

160M band operating and technical reference:

http://solar.spacew.com/cq/cqmar98.pdf

160m antenna URL references:

http://www.dxzone.com/cgi-bin/dir/jump2.cgi?ID=9005
http://www.iw5edi.com/ham-radio/?a-practical-antenna-for-160-metres,32
http://m0ezp.squirrelhouse.biz/160-base-loaded-inv-L.htm
http://topband.blog.cz/0612/a-practical-antenna-for-160m-by-alan-g4erz
http://www.hamuniverse.com/k6mm160metervertical.html

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Ft Tuthill 160M Basic Kit: 100.00 — Add

Ft Tuthill 160m Full Kit (with Digital Dial): 125.00 — Add

Digital Dial: 29.00 — Add

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TEXT LABELS ON YOUR HOMEMADE EQUIPMENT

(2000)

How to make simple text labels on your homemade equipment
We all know the problem: Building a nice cabinet around the just finished homemade equipment.
The solution I found is: Buy a standard housing and make text labels with a label printer. What you need are a label printer, a pair of scissors and that is it!

THE PROCEDURE

Step 1:

The equipment...

Step 2:

Make the text label with the label printer on clear tape with black text (or else if you prefer).
Set the text label printer to make a box around the text.

Step 3:

Cut the text label box with the pair or scissors.

Step 4:

Position the label carefully with a pincet.

[BACK TO INDEX PA2OHH](http://www.qsl.net/pa2ohh/)

A Beginners' Guide to Amateur Radio

What is Amateur Radio? - Many Hobbies in One!

What is Amateur Radio, what do radio amateurs do? Do I have to buy expensive commercial equipment, or can I build my own? Will I need massive aerials (antennas)? What kind of licence do I need? How do I get one? Do I need to pass technical exams and morse tests? Where do I start?

It can all seem a very daunting task at first.

This article is here to help you, so read on, and start to enjoy a very fascinating hobby.

Amateur (Ham) radio is not "CB". Operators are strictly licenced by various governments and enjoy many more privileges than do "CB" operators.

It allows millions to communicate worldwide using speech, computer data, and morse code, just to name a few.

Radio Hams can transmit and receive using **satellites**, and can send **TV pictures** too. Some even 'bounce' their signals off the **moon**.

Radio Amateurs have contributed to the advances in technology that we all enjoy today.

Some astronauts are also amateur radio operators, and they often take amateur radio equipment with them on space shuttle missions and talk to earthbound amateurs from space.

Amateur radio has many facets. It enables you to understand electronics. Its a great way to improve your geography, make new friends and practice your language skills, although almost all 'hams' speak some basic English, and exchange signal reports and station details in a mix of Q-code and English.

There are many specialised aspects to the hobby and whilst one amateur may be chasing rare DX (long distance) countries on the short wave (HF) bands, another may be designing and building a microwave aerial / dish, or building a new transceiver.

There are those who are more interested technical aspects of the hobby, and build their own equipment, and test out different aerials (antennas) etc. They may only have occasional contacts on the air to check out their latest experiment / project, or to discuss some technical point with a like minded friend.

Radio Amateurs also provide a valuable community service, frequently providing essential emergency communications for disaster relief and in times of national emergency, as they did in the Sep. 11 disaster in New York and the Asian Tsunami.

Transmitting Licences

A licence is necessary in order to transmit on the Amateur Bands, or frequencies. In most countries an Amateur Radio Licence is issued, for the purpose of self training, by the individual concerned, in the art of (all forms) of Radio Communication. A licence is not usually needed to "listen in" to Ham Radio transmissions.

Transmitting licence regulations vary in detail from country to country, but are broadly similar. Generally you will need to pass some form of technical exam. Technical Colleges and radio clubs provide the necessary training and examination centres.

Arrangements vary for different countries.

To transmit on the LF & HF short wave bands (Frequencies below 30MHz) some countries may still require the applicant to pass some form of morse code test in addition to the technical exam.

The morse code requirement has been eliminated in many countries, and many others are expected to do the same.

To encourage newcomers to the hobby, many countries now allow access to the HF (Short Wave) bands with minimal qualifications, but with reduced privileges, such as only using low power and certain frequencies.

These are often called Novice Licences. The UK in example, has a licence structure which has an entry level known as the Foundation Licence, which came into force in January 2002, an Intermediate Level, similar to the old Novice Licence, but with higher power, and the new Advanced Licence, which is the same as the former Full Licence with all privileges. In Italy instead there are no differences, and a single level Licence is provided.

To find out more about your country's requirements, contact your national society. You can locate many national societies or local radio clubs here.

There are licenced radio amateurs in most countries. All are issued with a **unique callsign** to identify their station which begin with prefixes identifying their country, eg, G, M & 2E for England, D for Germany, I for Italy, K,W,N for USA

Frequency Allocations and QSOs

Radio amateurs can contact each other on a variety of frequencies, or bands, that are allocated for their use. The bands are usually known by their approximate wavelength, e.g. 20 metres, which is a popular band for international communications, this wavelength corresponds to a frequency of around 14MHz The most popular bands are the HF, High Frequency, or short-wave, bands. These are in the 1.8MHz to 30MHz frequency range and the VHF or Very High Frequency. 144MHz, band, often referred to as 2 metres, from its wavelength.

Amateurs can make contact with others using speech, Morse, (CW), Radio Teleprinter (RTTY), digital techniques (including Packet Radio), Television (Fast and Slow Scan), and other modes.

A contact between two stations is known as a **QSO** (part of the International Q Code, used, when sending morse, to reduce the number of characters that need to be sent. It also helps to cross language barriers). This is usually initiated by an amateur putting out a "CQ", or general call, to announce that they are looking for a contact. Another amateur who hears this call can

then reply, and brief exchange of station details will then probably result. The contact may consist of little more than an exchange of signal reports, or it may develop into a longer, more conversational, exchange QSL cards and awards

Some amateurs exchange "QSL" cards to confirm the contact. These are often collected and can be used as proof to claim an award for contacting so many countries, states, or having collected so many points etc. To save money, such cards are often sent via a QSL bureau staffed by volunteers, or National Society. In this way, cards can be sent in bulk for one payment of postage.

Some amateurs prefer to send their cards direct, then you get to collect the postage stamps as well as the QSL cards! Increasingly cards are being sent electronically using e-mail

Equipment

Receivers

To listen to amateur radio transmissions, you need a communications receiver. The normal domestic radio is not normally suitable for receiving amateur radio short wave transmissions.

Even if it is, such radios are primarily designed for listening to high power commercial stations, such as the BBC World Service, Voice of America, Radio Moscow etc., and are not sensitive enough to receive the much lower power amateur radio stations.

Commonly such receivers cannot resolve SSB (single sideband) or FM transmissions from amateurs, as most commercial broadcasts are on the older AM (amplitude modulation) system.

To receive amateur short wave transmissions, your receiver should be capable of tuning 1.8 to 30MHz, and capable of receiving AM, CW, and SSB at least.

Transmitters / Transceivers

In order to communicate via radio, you need a transmitter, or transceiver, such as the one on the right. A transceiver is simply a transmitter and receiver combined into one unit.

Transmitters range from simple low power, low cost, devices, often only capable of sending morse, to complex multipurpose high power ones, and can be home built or commercially manufactured, the latter being the more common.

Cost

You don't have to spend a lot of money on expensive equipment to enjoy amateur radio, this is just the impression you could get from reading radio magazines!

Many 'hams' do not spend a lot of money on their hobby. When I first started I had lots of fun as a schoolboy buying government war surplus equipment, and converting it for amateur radio use, and you still can, although there is a lot less surplus equipment around now.

There are low cost kits so you can build up your station in easy stages.

To be able to build your own equipment, or modify existing, and use it on the air, generally you need to have a full amateur radio licence. The various kinds of novice licence usually mean you have to purchase low cost, low power commercial equipment.

Aerials (Antennas)

As with receivers, transmitters etc., you don't have to buy expensive aerials (also called antennas). Aerials do not have to be large and unsightly to be effective. Efficient short wave antennas can be constructed with nothing more than some ordinary thin flexible wire, at very little cost, should you have the room in a garden, or have some very accommodating neighbours.

How to become a Radio Amateur

A good way to start is to join your local club and / or National Society. There you will meet enthusiastic, like minded people, many of whom are only too willing to help you get started. Many clubs run courses to train you to pass the exams and assessments needed to gain a licence. They will also be able to help out with understanding your national requirements. You will be given the opportunity to experience amateur radio for yourself. The national society for the USA is the American Radio Relay League, ARRL. Try their website.

« back | print

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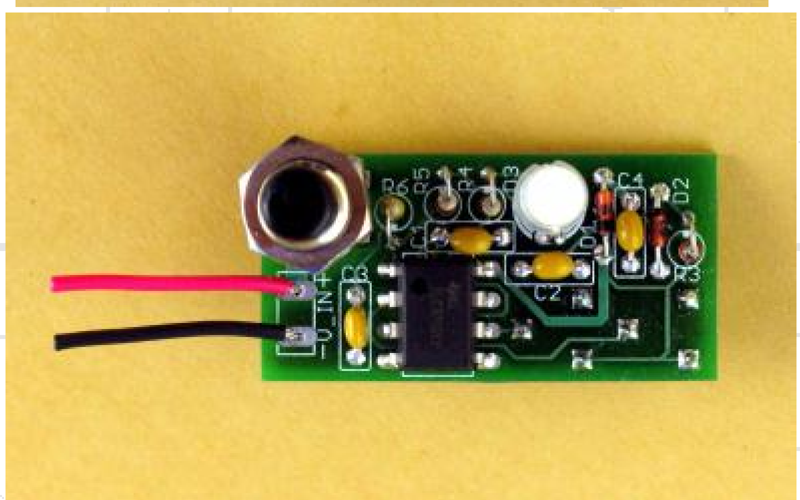
Battery Status Indicator Kit



Features

- Displays battery voltage using a 3 color LED
- LED changes color depending on battery voltage level
- Voltage points settable anywhere between 4.5 and 16 volts.
- Can be easily installed into a PFR-3 or other radio case
- Can be mounted to a case by drilling 2 holes
- Includes parts for both panel mount configuration or stand alone use.
- Board size of 0.75 × 1.5 inches

Manuals and other useful information

[Battery Status Indicator Builders Manual (ver 1)]

[Battery Status Indicator Board Mechanical Installation for the PFR-3]

Ordering Information

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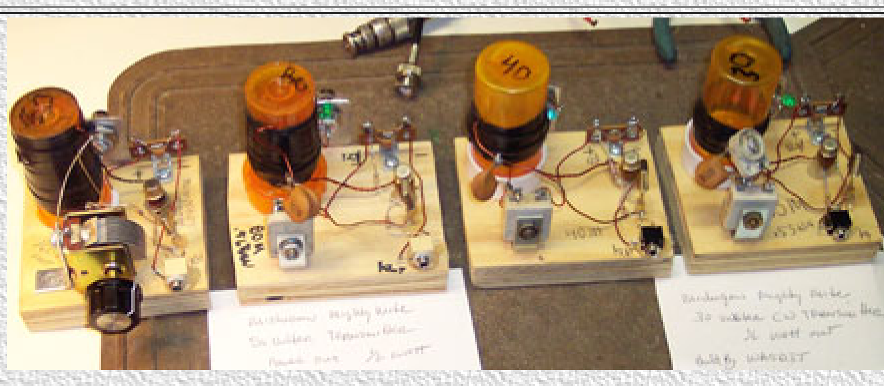
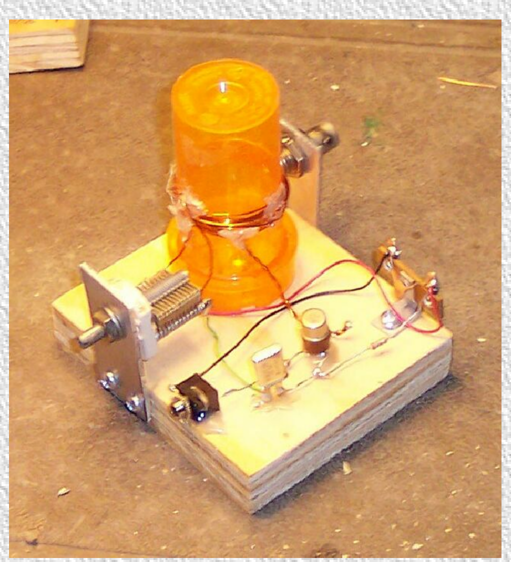
Michigan Mighty Mite's



Above is my bevy of Michigan Mighty Mite transmitters. It is the simplest transmitter I have ever built that gives such good performance. I have one for each of the following bands: 160 Meters, 80 Meters, 40 Meters and 30 Meters. Each are crystal controled and built with what ever parts I happened to have on hand. Each of these have a 2N2219 Transistor and each puts out about a half a watt. They all seem to be really clean and do not exibit the common chirp problem that many simple transmitters. As you can see no expense was spared in providing a first class Chassis. One of the simple modifications was to add a LED power output indicator on each of the antenna output lines, so I could tell when the transmitter was working. I use an external antenna change over switch and my ICOM-706MKIIG as the receiver. So far I have worked Radium Springs, New Mexico (about 20 miles from me) on 160 Meters and got a 549 signal report. It is a lot of fun to see just how far you can go with the "minimalist" transmitter.

Further information about this little transmitter can be viewed by clicking HERE

A 20 Meter Version



A 20 Meter version was first built by Harry KC5TRB of Tulsa, OK. He emailed me the changes to the basic Michigan Mighty Mite and they are as follows: The Coil is #20 enameled wire , 10 turns total with the tap at 4 turns from the bottom. He also changed the 27 ohm resistor to 15 ohms and the 10 Kohm resistor to 18Kohms. The Varriable Capacitor was changed to a 3.5pfd to 60 pfd. (Not too critical as you need about 1/3 to 1/2 of it to resonate the circuit on 20 meters. The crystal in this one is 14.060 and I get about 350 milliwatts out with no key clicks or warbles. So the word is now out. Harry renamed it to the 20 Meter Tulsa Mighty Mite. Since he made it I think it is only fitting.

**UPDATE: Got an email from Harry on 1/9/2007. He hung his 20 meter Tulsa Mighty Mite with
a KID cw IDer outside and let it run. He received a QSL from Doug KK6D in Riverside, CA
a distance of 1200 miles. Not bad for only 350 mw and a wire antenna. Harry also miniturized the
transmitter into a 35 mm film can for this beacon project. I think it is also getting ready for a
future ballon ride. If you would like to see what he did ... click here**

Hope to catch some more of you Michigan Mighty Mites on the air out there. If I can help answer any questions, give construction hints, or help with parts and substutions please contact me at dhassall@zianet.com

Good Luck

back to Dave's Ham Radio Projects page

- Home
- Antennas
- New Products
- Antenna Accessory Kits
- Transceivers
- Transmitters
- Receivers
- Accessories
- Easy Series Kits
- Kits for New Builders
- Voltage Monitor Kits
- Audio Kits
- Keyer/CPO Kits
- RF Amplifier Kits
- Frequency Indicator Kits
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- Power Management Kits
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- Test Equipment
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- Parts and Stuff
- Keys and Paddles
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KD1JV Survivor 75m SSB transceiver

Specifications

- ~10 PEP @ 13.8V
- 0.2 uV receiver sensitivity
- 5 pole crystal ladder filter for selectivity
- 325 or 175 kHz tuning range, selectable at build
- Coarse and Fine tuning controls
- 8 ohm - 500 mW speaker output
- SSB, CW, and, "TUNE" mode
- 50mA Rx current (with optional Digital Dial)
- Inexpensive electret microphone input
- All through hole construction
- Professional silk screened and solder masked pcb
- Full aluminum chassis w/bail, cutout for optional digital dial
- Small size, 6" x 4" x 1.5"
- Assembled weight, w/dd: 330g./11.6 oz.
- 13.8 @ 2A, min. recommended power supply

Manuals and other useful information

[KD1JV Survivor Construction Manual rev B (11/13/2017)]

[KD1JV Survivor Construction Manual (Spanish version) (3-12-2013)]

[Revised Assembly instructions for the Bail]

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Survivor Full Kit (with Digital Dial and Microphone): 165.00 — Add

Survivor Basic Kit (less digital dial and microphone: 125.00 — Add

Digital Dial: 29.00 — Add

Microphone: 15.00 — Add

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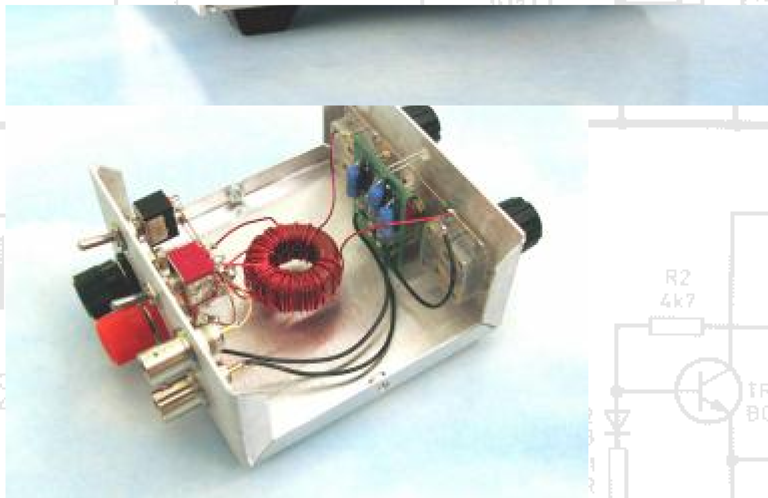
Balanced Line Tuner Plus



Description

- The BLT is a simple Z-Match tuner that works from 10-40 meters.
- Tunes balanced feedlines.
- Handles up to 10W.
- Includes LED SWR indicator
- All parts for the tuner and a case are included.

Supporting Files and Documents

BLTPlus Tuner Construction Manual -- 1.5 MB (rev 2.2)

BLTPlus Decal Installation Instructions

Review

"Got mine finished last night and never have I had a kit that I put together work the first time. The BLT tuner worked great. Just had the diode in backwards but that was easy to fix. Doug has made one of the best manuals for a kit that I have seen. Photos are great and sure help you keep on track. This kit would be great for the first time builder. It was great to see the LED go out on 40 meters. Doug you have set the standards for a user manual. A big thanks!"
... *72 Gene N0MQ*

Ordering Information

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Balanced Line Tuner Plus: 60.00 Add

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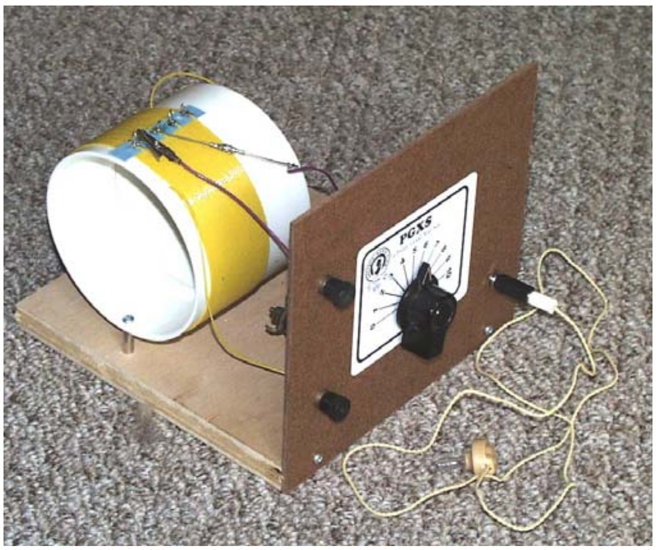
A Pretty Good Crystal Set – Mark II

By Al Klase, N3FRQ, http://www.skywaves.ar88.net/

This is a revised version of the original New Jersey Antique Radio Club PGXS with minor changes to improve performance with short antennas in strong-signal areas. This radio will give a good account of itself on the AM broadcast band.

OK! It's time to build a crystal set. This time it's going to be a good one.



Countless millions of crystal radios have been built over the last 100 years, but the performance of most of these leaves a lot to be desired. The design of this radio goes back to about 1990 when I was a den leader for my son's Cub-Scout pack. I wanted the guys to have the experience of listening to a radio they had built with their own hands. However, we were in the deep suburbs of Philadelphia (actually half way to Reading). There were no strong local stations, so an average crystal set combined with the sort of makeshift antenna most families would erect, wasn't going to get the job done. The result was the Den Two Crystal Radio. (See "Crystal Set Projects," The Xtal Set Society, 1997.) This radio was based on a spider-web coil that 10-year-old hands could wind with a little supervision. It was sensitive enough to hear distant sky-wave stations at night, and selective enough that you could usually listen to just one station. Seven were constructed and at least six of those went into service at home. Everyone was duly impressed. We even had reports of hearing Radio Japan! (That was from Ontario, however.) We'll use the same circuit with a better solenoid-style coil.

Selecting Components

First, let's deal with the headset. Look around for a traditional pair of 2000-ohm 'phones. That's the DC resistance, they'll have an AC impedance of about 10,000 ohms. Test the 'phones by putting them on your head, holding on to one of the tips and touching the other to an electrical ground such as a water pipe or the screw on an outlet plate. You should hear a click or maybe a hum. If not, they probably won't be sensitive enough for our purposes. Check the DC resistance with an ohm meter, it should be in the range of 1-5 K-ohms. Sometimes the cords are open.

An acceptable alternative to a vintage headset is one of the crystal (ceramic) ear plugs available from Mouser.com for about two bucks. It's best to install a 50-100K

resistor in parallel with these capacitive devices to provide a DC load for the detector to eliminate audio distortion.

Modern low-impedance headsets with a matching transformer might work if you have a lot of signal strength, but most are designed to sacrifice sensitivity for flat frequency response.

Next comes the detector. Stick to a germanium diode or the base-emitter junction of a germanium transistor for openers. A digital voltmeter in the diode position will indicate the forward voltage drop. Germanium devices will show 0.2-0.3 while silicon will indicate 0.5-0.7 volts. You can use a modern silicon device, but you'll be giving up a lot of sensitivity. The basic germanium diode is the 1N34A, but the part number doesn't mean much. They vary widely. Dump out the junk box, try them in a radio, and pick the best one. You can move on to mineral detectors and cat's whiskers for a little nostalgia after you have a working radio.

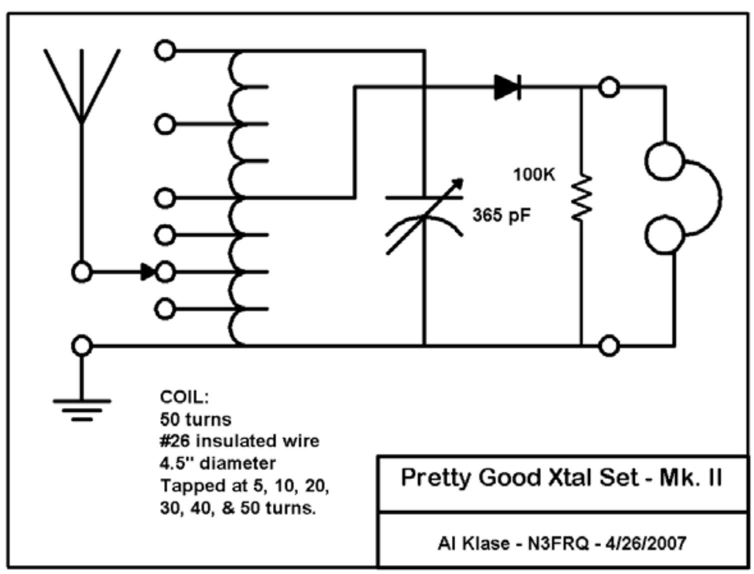
Now you'll need an antenna, the higher, longer, and more in the open the better. Sixty feet long and forty feet high would be excellent, but wire in the attic will probably suffice, especially if you're a "city mouse." A wire to a hose clamp around a water pipe or a connection to the screw on an outlet plate (AC safety ground) will complete the antenna-ground system.

Start Simply

Now it's time to build the simplest possible radio: Clip-lead the diode across the headset and then connect one side to the antenna and the other side to ground. You should hear something, quite possibly three stations at once. This will verify that you have a usable headset and detector, and that you have enough antenna for the available signals.

Construction of the PGXS

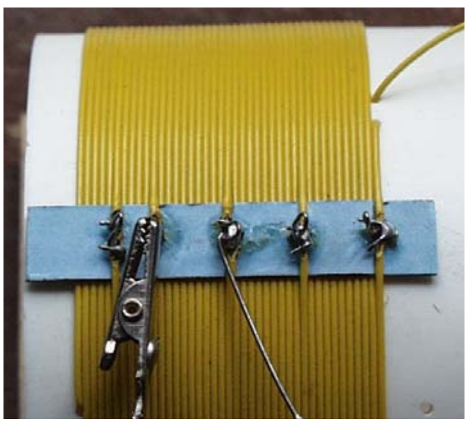
To make this kludge into a serviceable radio we'll add a resonant "tank" circuit consisting of a coil and a variable capacitor to allow us to select the station we want to hear. The coil has multiple taps so it can serve as an autotransformer to achieve a good impedance match, allowing optimal energy transfer, between the antenna-ground system and the tank circuit as well as between the tank and the detector and it's load, the headset.



The target value for the cap is 365 pico-farads (mmF or pF), but a 500 pF unit as found in some of the old battery sets will work nearly as well. You could also use the large half of the two-gang cap from a junked all-American-five radio, etc.

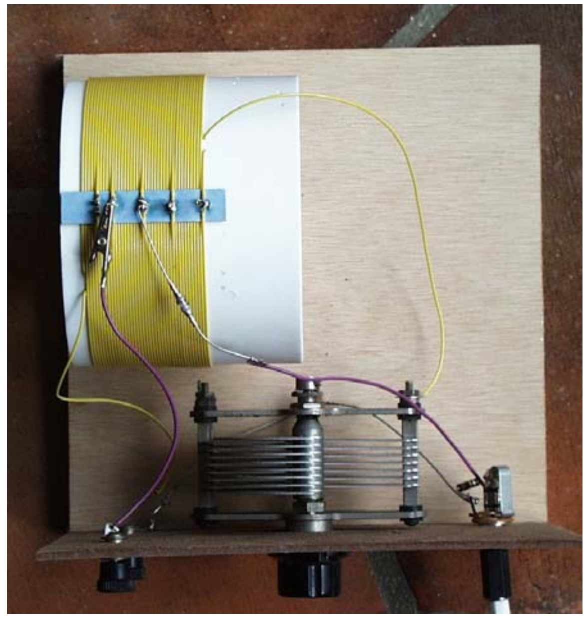
The coil is wound on a 4-inch ABS pipe coupling from the "home center." Wire is generally expensive and hard to buy retail. You can use #20 insulated bell wire, also from the "home center" because it is easily available. The down side is that it's twisted pair that needs to be untwisted, and they make you buy 500 feet, for about 30 bucks, when you only need 85 feet for the project. Any plastic insulated wire between #26 and #20 will do, but you may need to adjust the total number of turns after you get the radio working to cover both ends of the broadcast band. The best option, for maximum performance, is silver-plated Teflon-insulated hook-up wire if you have any in the junk box, but even common vinyl-insulated tinned stranded wire will work just fine. Close-wound enameled magnet wire is a bad bet, as eddy currents in the closely spaced turns cause considerable loss.

Winding the coil: Tie one end of an 85-foot length of wire to a solid support. Drill two small holes about 3/8 of an inch from the end of the coil form. Keep the drill handy. Put your wire cutter and a strip of thin cardboard about 3/8 inch wide and 3 inches long in your shirt pocket. Lace the end of the wire into one hole and out the other, leaving about a foot protruding from the form. Grasp the coil form firmly and pull the wire taught against the tied off end. Wind 5 turns on the coil keeping the wire close-wound and tight. Place the end of the cardboard strip under the 5th turn. Wind four more turns, sneaking them under the strip. Wind the 10th turn over the strip. Continue winding placing the 20th, 30th, 40th, and 50th turns on top of the cardboard. Holding the wire firmly in place with your left thumb, clip the wire leaving about a foot to terminate the coil. Drill two more holes in the form just beyond where the 50th turn crosses the cardboard, and lace the end of the wire through them.



Use a utility knife to whittle away the insulation where the turns cross the cardboard. Wrap and solder a piece of bare wire at each of these sites to form the coil taps.

“Beadboard” the radio with clipleads or tack-solder joints to make sure everything works before committing to a physical design.



The radio in the picture is built on an 8-inch square piece of ¾” plywood with an 8 x 6-inch front panel of tempered hardboard. An alligator clip is used to connect the selected coil tap to the antenna terminal. The 100K-ohm diode load resistor is installed on the ¼-inch phone jack. An adaptor is used to plug in the ceramic earpiece. Print out and paste the dial scale to the front panel. A large knob with a pointer is the way to go. You can install a rotary switch for the coil taps if you want to get fancy. Layout is not critical, but keep the coil in the approximate orientation shown so it can be coupled to the antenna tuner to be described in “Phase II.”

Operation

Connect the antenna, ground, and headset. Put the alligator clip on the middle tap where the diode connects. Tune in a station. Move to another tap, and retune looking for the best performance. The optimum coil tap will be dependent on the frequency your tuning.

In strong signal areas, you can just connect your ground wire to the top (right most) tap. The headphone cord and your body will serve as the antenna.

A reasonably high 50-75- foot outdoor antenna should allow you to hear night-time stations hundreds of miles away.

Some Helpful Links

The author’s website: http://www.skywaves.ar88.net/

The Radio Technology Museum: http://www.rtm.ar88.net/

The New Jersey Antique Radio Club: http://www.njarc.org/

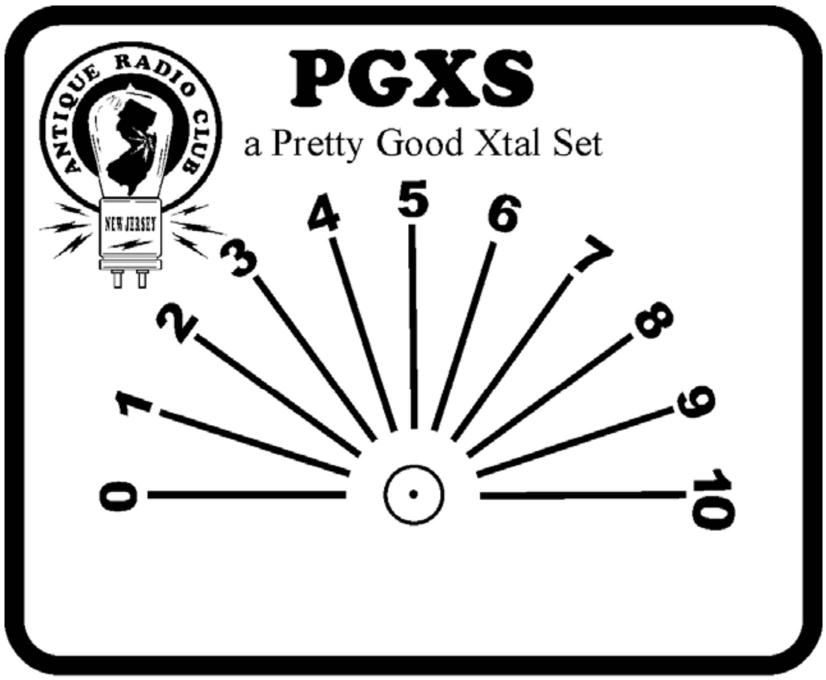


Figure 1 - Dial Artwork. Print on label stock.

du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Saturday, June 10, 2017

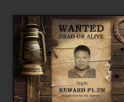
180W Pallet Amplifier Using MRF9180

This is my first time to play with the 180W pallet amplifier kit from China. The kit comes with only a printed schematic but there was no details for the input transformer and the coaxial balun. The bias for the LDMOS is not also indicated so I have to download the datasheet of the MRF9180 from the internet.

The input transformer has a 9:1 impedance ratio so it has a 3 turns in the input while a single turn in the output. Connected to the drains are the 25 ohm teflon cables. This coaxial transformer is responsible for stepping up the low impedance drain to approximately 25 ohms. Next is a 50 ohm cable used to combine the 25 ohm balance signal into 50 ohm unbalance at the output. I choose to cut this cable to 15cm so that pallet operation would be optimal at the fm broadcast band.

The datasheet says that for MRF9180, gate voltage bias may be set anywhere between 2 to 4V but in my amplifier the VGS was set to 2.2V. At full output power, the pallet amplifier is consuming around 8 to 10 amps at 24V dc supply.

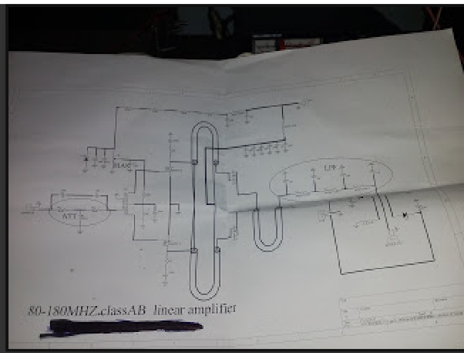
About Me



hevirred

Ham since 2000.

View my complete profile



After the test, I was getting 150W at 144MHz (2W) drive and 200W at 100MHz (1.5W) drive and this pallet amplifier is remarkably broadband. The test was conducted without the LPF at the output.
--- 73 de du1vss.

Posted by hevirred at 4:45 AM

3 comments:

Jaroslav Jelšovský June 27, 2017 at 11:20 AM

Hi how do i wound the transformer tr1?

Reply

hevirred July 1, 2017 at 1:59 AM

The transformer is a 1:9 therfore the turn ratio is 1:3, the single turn goes to the gates of mosfets while the 9 turns is the rf input.

Reply

Jaroslav Jelšovský July 24, 2017 at 8:15 AM

thanks

Reply

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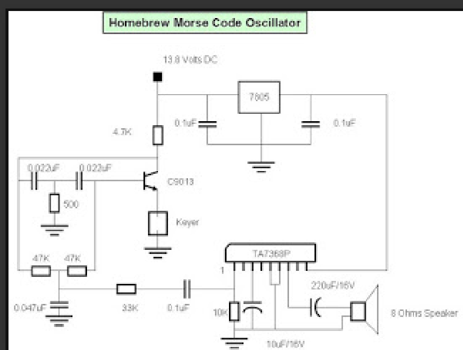
du1vss home brews

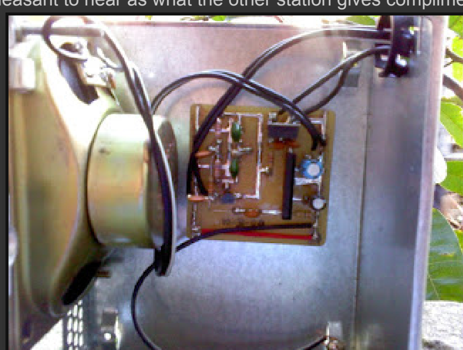
All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Monday, November 2, 2009

My Home made Morse Code Keyer and Oscillator



Learning morse code is fun and exciting. At first, I don't see the importance of it thinking that this is just an obsolete form of communication. With the encouragement and help of my friends on the air, I was hooked with it and began to search different circuits about the morse code oscillator. I started with the 555 timer IC taken from my ARRL 1989 edition handbook but the audio quality of the oscillator was very irritating to my ears. This was due to the inherent square wave output of the 555 IC. Several search in the internet brought me the idea of constructing an audio oscillator that will generates a pure sine wave at 800Hz. In my project the circuit was the popular Bridge-T oscillator and then feeds to an audio amplifier to increase the output audio. The resulting output tone was nice and pleasant to hear as what the other station gives compliment to my oscillator.



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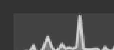
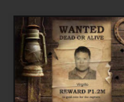


45,115

About Me



hevirred

Ham since 2000.

View my complete profile

The PCB board and the speaker were enclosed on an empty CPU power supply casing. On the side of the casing, my homemade straight key is mounted using a contact cement. The straight key was constructed using a hard disk motor. Kindly check the attachment for the oscillator circuit. ---73 de hevir

Posted by hevirred at 8:40 PM

No comments:

Post a Comment

Enter your comment...

Comment as: Karl Smirni (Gc

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VHF YAGI (BEAM) ANTENNA FOR 2M RIG

— By N.S.Harisankar, Palakkad.

1.	Low SWR	-	1 : 1.2	5.	Gain	-	10 dB
2.	Elements	-	12	6.	Power Rating	-	200W
3.	Matching	-	Gamma	7.	Impedence	-	50 Ohms
4.	Frequency	-	144 To 146 MHz				

Yagi Antenna consists of three parts - reflector, dipole and director. It has a gain of 6 dB or more depending upon the number of director's used. Yagi Antenna does not transmit or receive in the direction of the Reflector but only in the direction of the directors it is like a torch light which radiates a Powerful beam of light in one direction.

In this beam (Yagi) antenna Gamma match is used for matching transmission line to antenna at low SWR. Raise the antenna to about 5 ft from the grouad level, preferably in a vacant spot. Connect a good SWR meter to the Yagi. In the forward direction while transmitting for the full scale deflection. Now change to the Reverse direction (Reflected) while transmitting slide the stub to get the minimum reading. Now your antenna is SWR matched. The Beam antenna gives 10dB gain and also Power handling capacity up to 200W. Use RG 213/RG8U for Best Results.

"Wishing you, good Dxing with 2M Yagi"

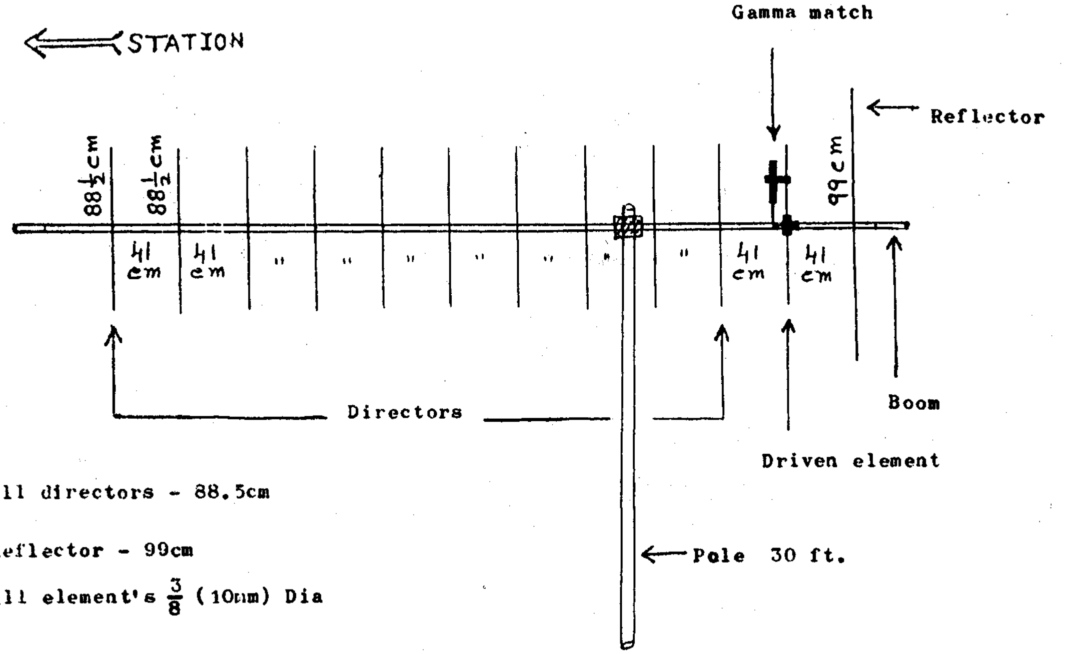
73's

$$SWR = \frac{F + R}{F - R} \text{ if 'F' = 10 and 'R' = .5, SWR is } \frac{10 + .5}{10 - .5} = \frac{10.5}{9.5} = 1.105 = 1:1$$

F = Forward R = Reflected

(1)

2M 12 Element Beam



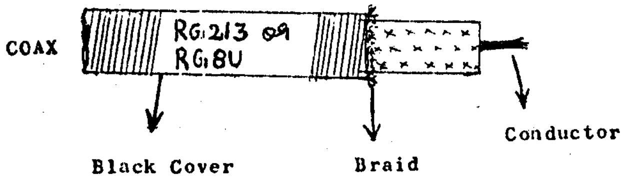
All directors - 88.5cm

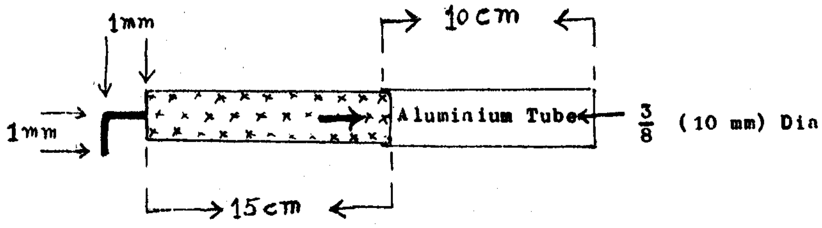
Reflector - 99cm

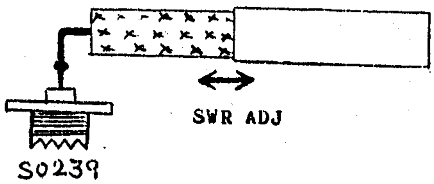
All element's $\frac{3}{8}$ (10mm) Dia

STUB for Gamma Match

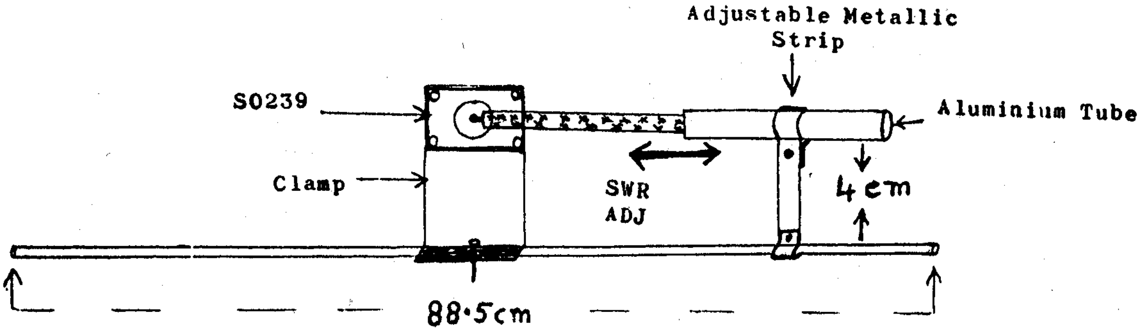
(2)



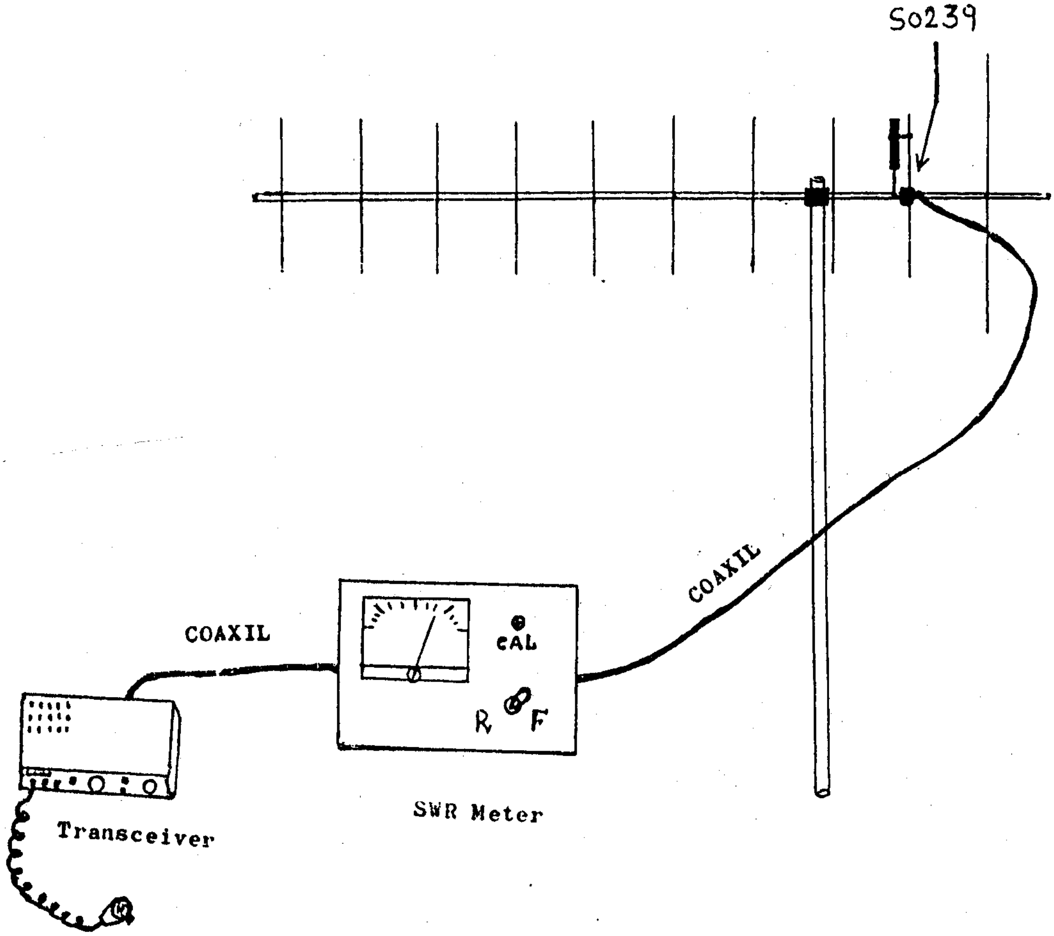




Driven Element & Gamma Match (3)



Measuring The SWR (4)



Pacific Antenna

Affordable QRP Antennas and Kits at exceptional value

Switched Longwire Tuner Plus

Description

- The SLT+ is a Switched Longwire Tuner.
- Perfect tuner for hikers, backpackers, campers.
- Kit comes complete with all parts, wire and circuit board.
- Includes a brushed aluminum case and decals.
- Needs just one support and a length of wire.
- Covers 10M - 80M.

Supporting Files and Documents

Switched Line Tuner Assembly and Operation Manual (10/4/2017)

Bottom Label

Ordering Information

To order this kit, use the buttons below. (you do not have to have a PayPal account to pay for items using a credit card)

NOTE
Use Add to cart buttons to add an item to your shopping cart. Use "Continue Shopping" tab to go back and add multiple items to your cart. You can view shipping charges before making payment. Payment can be made by Credit Card, Debit Card or by Paypal. Selecting "Checkout" in your shopping cart will allow you to use a credit card rather than Paypal Please be sure the address you supply is correct. We receive an automated notification when you complete payment. Your order will be shipped as soon as possible unless otherwise stated. Thanks for your support!

Switched Longwire Tuner Plus: 70.00

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Pacific Antenna Return Policy

Multi-band, Direct Conversion CW Transceiver (MBDC)

Description

The MBDC (Multi-band, Direct Conversion) CW transceiver is a two band kit covering the 160 and 80 meter ham bands. It also has a DDS VFO and general coverage reception capability from 100KHz to over 21 MHz. Since the MBDC has a direct conversion receiver it is capable of reception of CW, SSB and AM signals. Additionally, the MBDC includes a second antenna input for general coverage reception and a control line for use with a pre-selector, preamp or external RF amplifier.

Features and Specifications

- DDS VFO with knob tuning and 2X16 backlit LCD display
- Direct conversion receiver for all mode reception
- Sensitivity: ~ -90 dBm (5 uV)
- Covers both 80 and 160M bands plus 100kHZ to 21.5MHz general coverage receive
- Can be converted to any two of 40, 30, 20 or 17M bands
- Can be configured for operation on Lowfer bands
- Programmable band limits
- Auxiliary receiver antenna input for general coverage reception
- Three audio bandwidth settings and 20 frequency memories
- Control line for external amplifier
- Iambic B mode keyer with message memories and beacon mode

- 80 M : 70 mA receive , 620mA transmit @ 5W
- 160 M : 100 mA receive , 810mA transmit @ 5W

Manuals and other useful information

MBDC V2 Construction Manual

MBDC Decal Instruction Manual

Ordering Information

To order this kit, use the buttons below. (you do not have to have a PayPal account to pay for items using a credit card)

Payments are Fast and Secure with PAYPAL

NOTE
Use Add to cart buttons to add an item to your shopping cart. Use "Continue Shopping" tab to go back and add multiple items to your cart. You can view shipping charges before making payment. Payment can be made by Credit Card, Debit Card or by Paypal. Selecting "Checkout" in your shopping cart will allow you to use a credit card rather than Paypal Please be sure the address you supply is correct. We receive an automated notification when you complete payment. Your order will be shipped as soon as possible unless otherwise stated. Thanks for your support!

MBDC Transceiver: 200.00 Add

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Pacific Antenna Return Policy

Non-contact Probing of RF Circuits with the Beehive 100 Series Probes

Introduction

As RF products become more integrated, testing them becomes for difficult. High levels of integration reduce the number of separate assemblies in an RF system, frequently integrating the entire product into one printed circuit board. Because cables and coaxial connectors have been eliminated, it is no longer possible to simply connect test equipment to a suspect circuit through a coaxial cable.

For example, when it was necessary to test the local oscillator in a microwave transmitter, one could previously connect a spectrum analyzer to the oscillator's output and measure the signal power and frequency directly. Today, the entire signal chain might be integrated on one printed circuit board, with the only accessible RF interconnect being the connection between the transmitter and the antenna.

For these reasons, various probes and probing techniques have been developed to allow technicians and engineers to measure RF signals on the printed circuit board itself. This article highlights the advantages of using passive non-contact probes for this work.

Contact vs. non-contact probes

Most high frequency probes are contact probes. In other words, they rely on a direct electrical connection between the probe and the circuit to be measured. This technique works, but suffers from several disadvantages: Loading, ground inductance, and usability.

Loading: A typical high-frequency active probe has a relatively high DC resistance, but a capacitance in the range of 0.5 to 1.0 pF. While this capacitance is acceptable at low frequencies, at RF it can pose a significant problem. For example, 1 pF represents a shunt reactance of 80 ohms at 2 GHz. Passive probes may have lower capacitance, but at the price of significantly lower resistive loading; often as low as 1000 ohms.

In contrast, non-contact probes have no DC loading at all. Because they do not actually touch the circuit under test, their capacitive loading is also extremely low.

Ground inductance: A ground connection is required for contact probes. Making this connection, however, can be quite difficult. A long ground wire will add excessive inductance to the probe, resulting in a poor frequency response. A very short ground wire is necessary at RF frequencies. However, very short ground connections are very difficult to work with.

Usability: These very short ground connections are one of the things that make high frequency active probes difficult to use. Rather than a clip lead, a short, stiff ground probe is usually part of the probe tip. Anyone who has ever used these knows how difficult it is to simultaneously make a signal and ground connection with their probe using one hand, while using the other hand to operate equipment and make measurements. It takes the skill of a surgeon hold the probe steady enough so that contact is maintained; if the probe slips it could inadvertently short the circuit under test to ground, possibly destroying it.

Non-contact probes solve all three of these problems. Since there is no direct connection between the circuit and the probe, loading is extremely small. Since there is no ground lead, ground inductance is not an issue. And, since the probe tips are insulated, accidental shorts are impossible.

E-field vs. H-field probes

Non-contact probes do not measure voltage or current directly. Rather, they measure the electromagnetic fields that surround a conductor.

E-field probes measure the electric field around the conductor; the magnitude of the E-field is proportional to the conductor's voltage. H-field probes measure the magnetic field around a conductor; the magnitude of the H-field is proportional to the conductor's current.

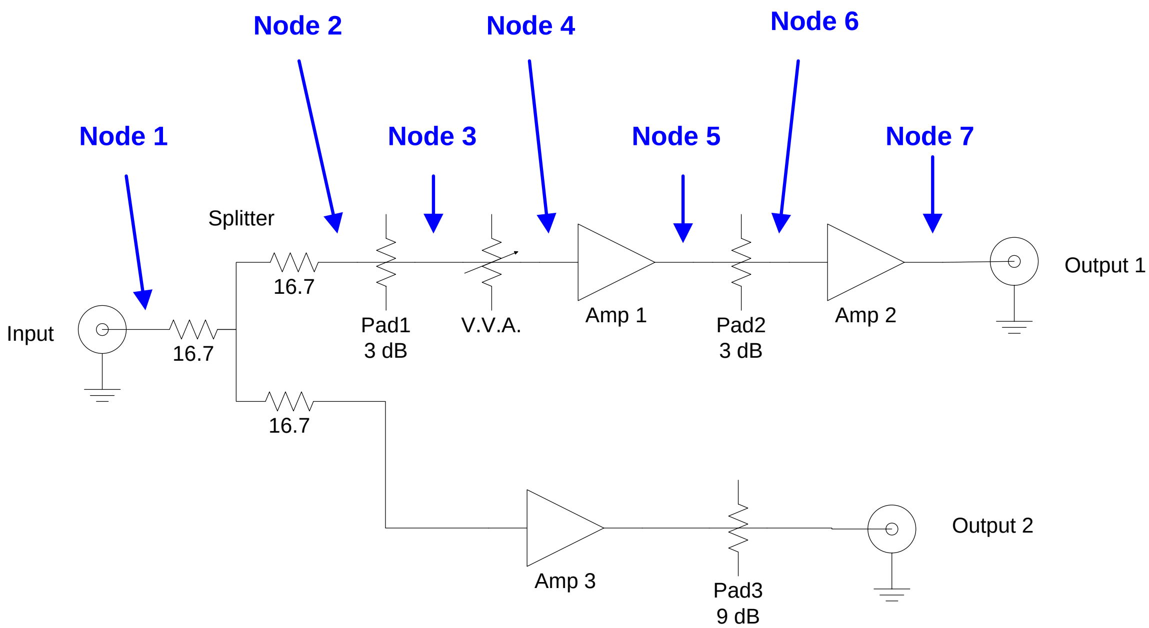
At low frequencies, the impedance of a circuit node can be very high or very low, and as a result the relative magnitude of the E and H fields can vary. In a high-impedance circuit, the voltage is relatively high and the current is relatively low; in this situation an E-field probe will display better sensitivity. In a low-impedance circuit, the situation is reversed.

As frequencies climb into the RF range, these extremes of impedance are no longer practical to realize, and there is less possible sensitivity difference between E and H field probes. However, the different types of probes still have unique characteristics. The primary advantage of E-field probes is their fine spatial resolution. Since they have a narrow tip, it's possible to isolate signals down to specific pins on an IC. H-field probes, since they have a circular loop for their tip, are less proficient at this. A smaller loop will offer better spatial resolution, but at the cost of reduced sensitivity. A larger loop will have better sensitivity, but will have less accurate spatial resolution as well as less accurate high-frequency response. For this reason, Beehive Electronics sells a series of H-field probes with different loop sizes, allowing the user to select the optimum probe for the frequency of interest.

The disadvantage of E-field probes is common-mode currents. A source of electric fields can induce a current to flow in the probe, but also can induce a current to flow on the outer conductor of the probe's coaxial launch. These surface currents can be affected by, for example, placement of the user's hand, causing a lack of repeatability in the measurements. In poorly designed probes, this effect can cause a variance of several dB as the user moves his hand along the probe. Beehive's 100D E-field probe is designed to minimize this effect, so the variation is less significant. Beehive's 100A/B/C H-field probes have integrated electric-field shields, so they are essentially immune to this problem.

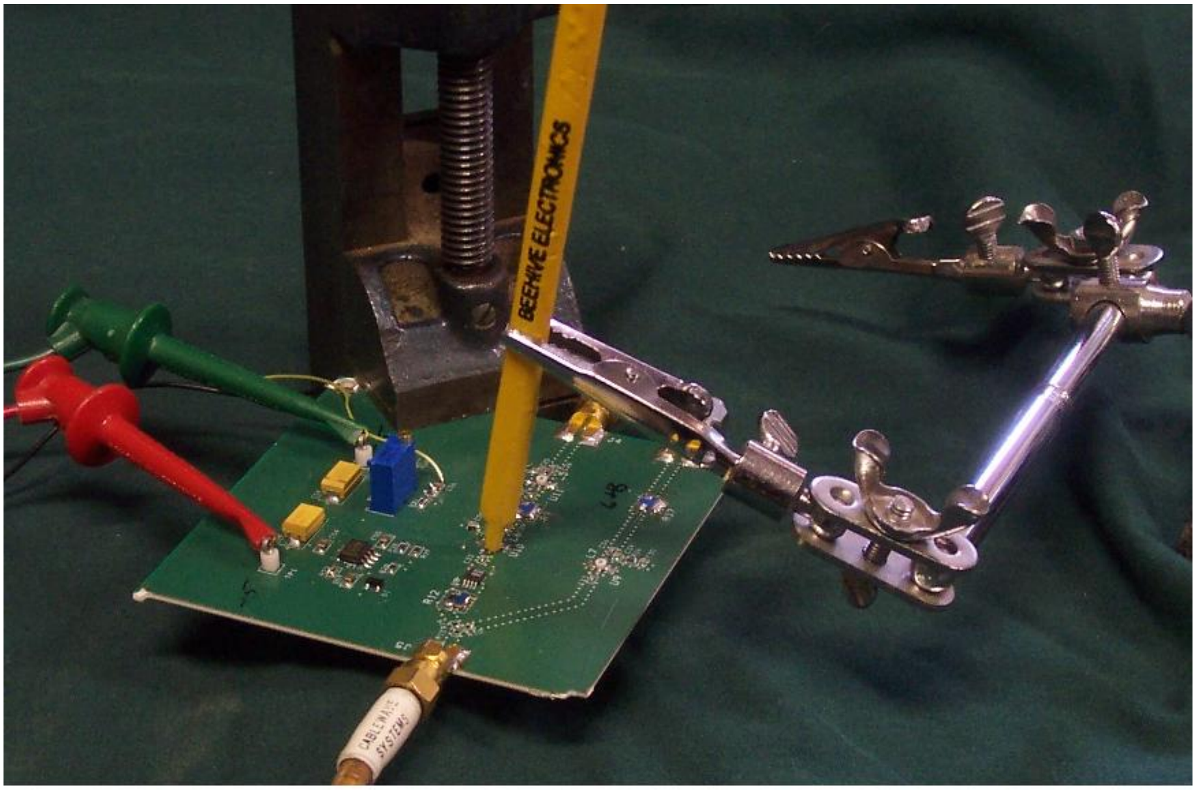
Example measurement of two-port devices

To demonstrate the feasibility of using non-contact probes for RF troubleshooting, the test circuit shown below was measured.



Test Circuit Block Diagram

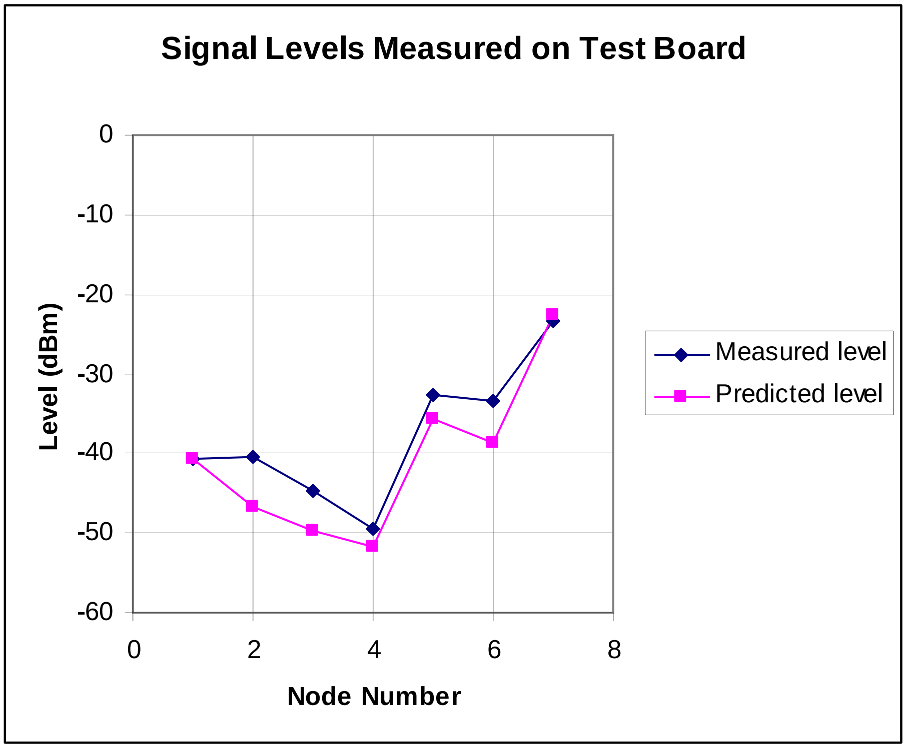
A signal generator was connected to the input; the input signal had a frequency of 1 GHz and an amplitude of 0 dBm. The RF output connectors were terminated with 50 ohm loads. A Beehive Electronics 100D E-field probe was used to measure the signal levels through the signal path between the input and Output 1. The following photo shows the setup:



Although the photo shows the probe being held with an alligator clip, the probe was actually hand-held when the measurements were made. At each of the nodes labeled in the block diagram, a measurement was made using the 100D probe. The probe output was attached to a spectrum analyzer tuned to 1 GHz.

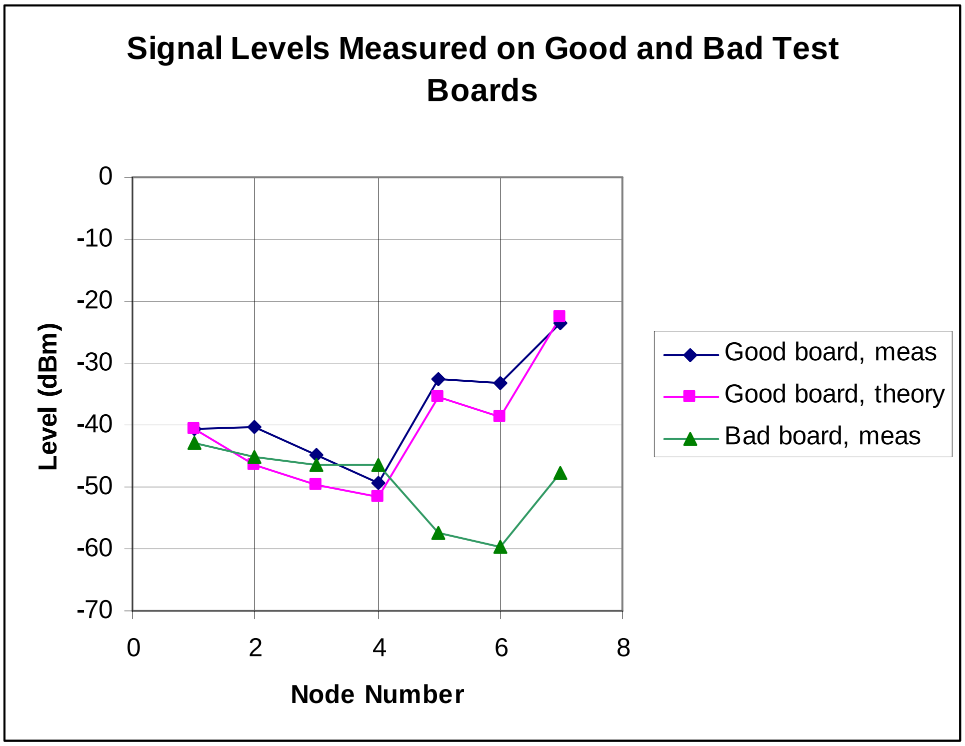
The measurements made at each point were compared to the expected value. For example, if the power level measured with the probe was -40 dBm at node 1, we would expect the power level measured at node 2 to be -46 dBm, based on the nominal 6 dB loss of the splitter.

The following graph shows the measured and predicted signal levels throughout the signal chain.



Overall, we can see that the measured signal levels follow the predicted levels throughout the chain, with a node-to-node error of a few dB.

Next, we induced a fault in the board. We disconnected the power supply from amplifier #1. This simulates a fault that one might typically see on a production PCB, where a bad solder joint could cause an open circuit in an amplifier's bias network. The measurements were then repeated at each of the nodes. The results are shown in the graph below.



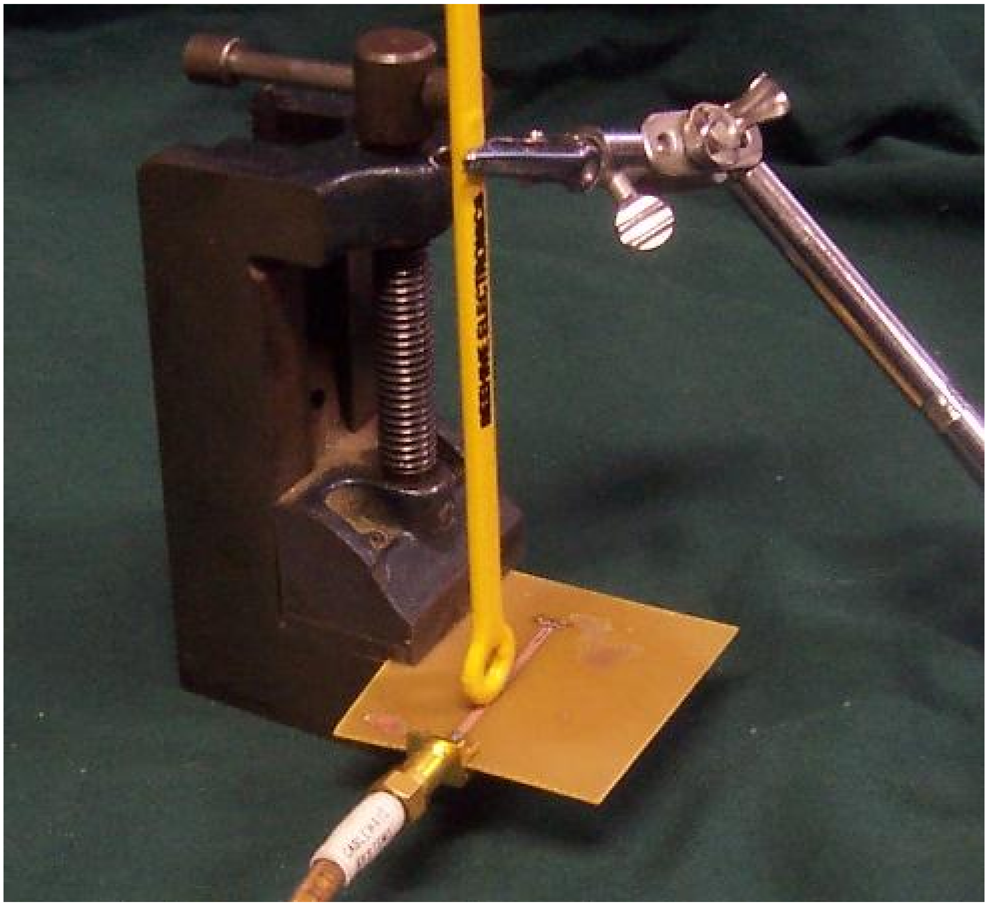
Here we can see a dramatic difference in the signal levels starting at node 5, the output of amplifier #1. It's clear that the measurement repeatability of the non-contact E-field measurement is sufficient to track down the fault.

The power of this technique becomes particularly obvious when considering the time involved. No time is required to break the signal chain or to solder probes to the PCB. No care need be taken to find or create nearby ground connections. The total time to measured the signal level across all seven nodes and find the defective part was approximately *one minute*.

Calibrated non-contact measurements

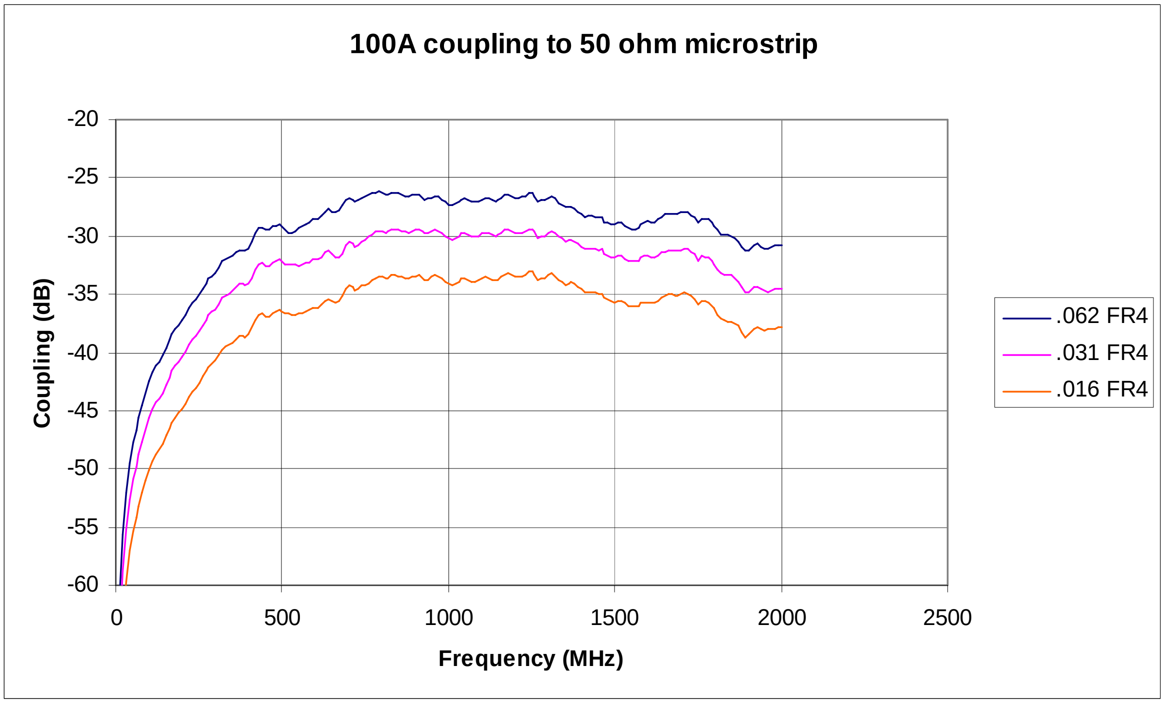
The previous example used relative power measurements. The faulty amplifier was identified by comparing the power level at the input to the amplifier and at the output. However, sometimes it is desirable to make an absolute power measurements. For example, an oscillator is a one-port device. Without an input port to establish a reference, it's difficult to predict what power level one might expect when measuring the oscillator output with a probe.

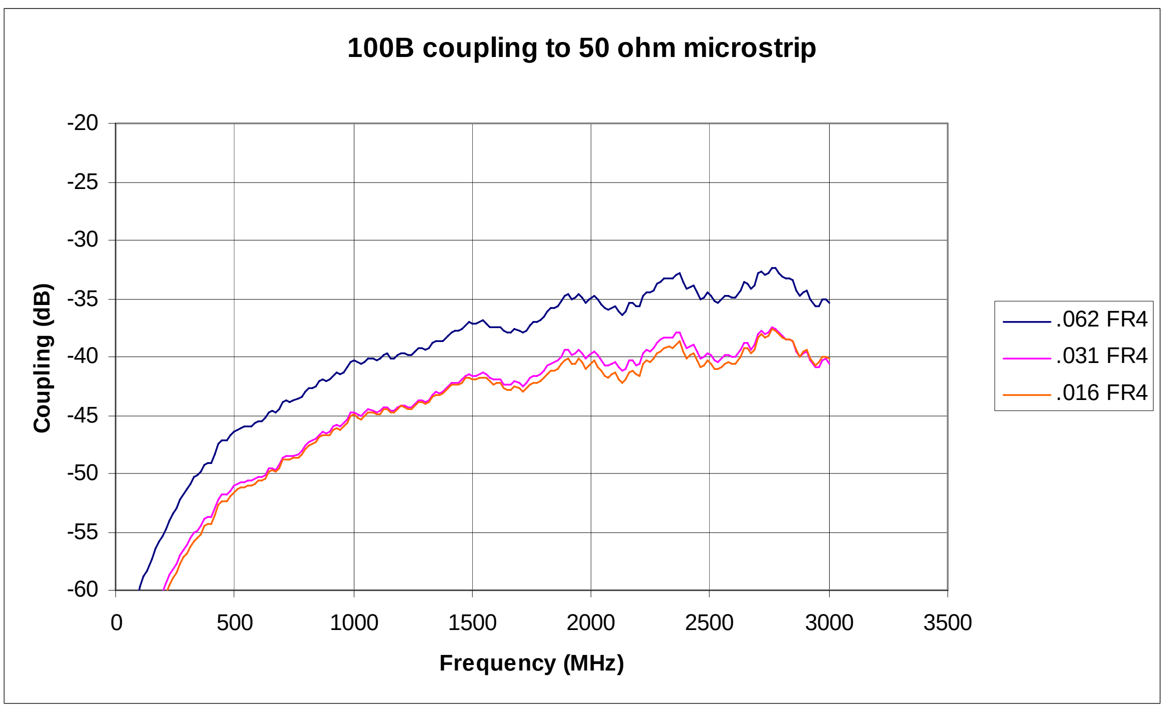
To this end, we measured the coupling between microstrip lines and the Beehive probes for microstrip lines of several thicknesses. 50 ohm lines were fabricated on 0.016", 0.031", and 0.062" thick FR4 with on-board 50 ohm terminations. The coupling factor between the line and probe was measured using a vector network analyzer. A photo of the test setup is shown below.

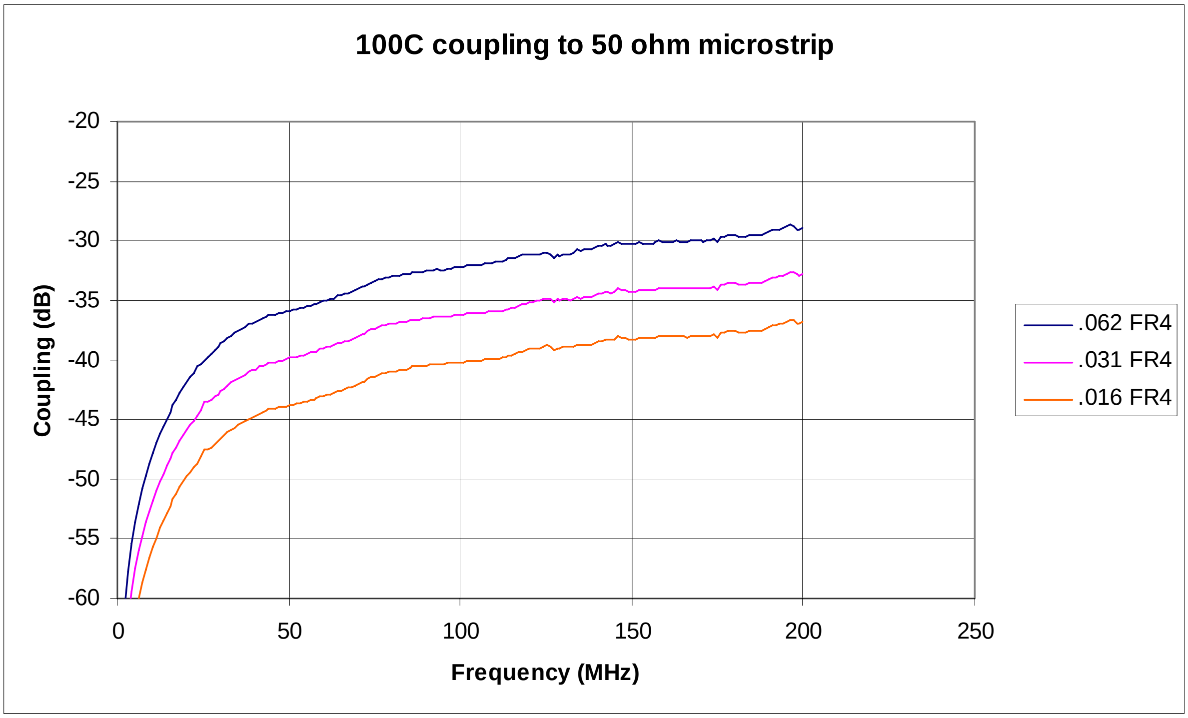


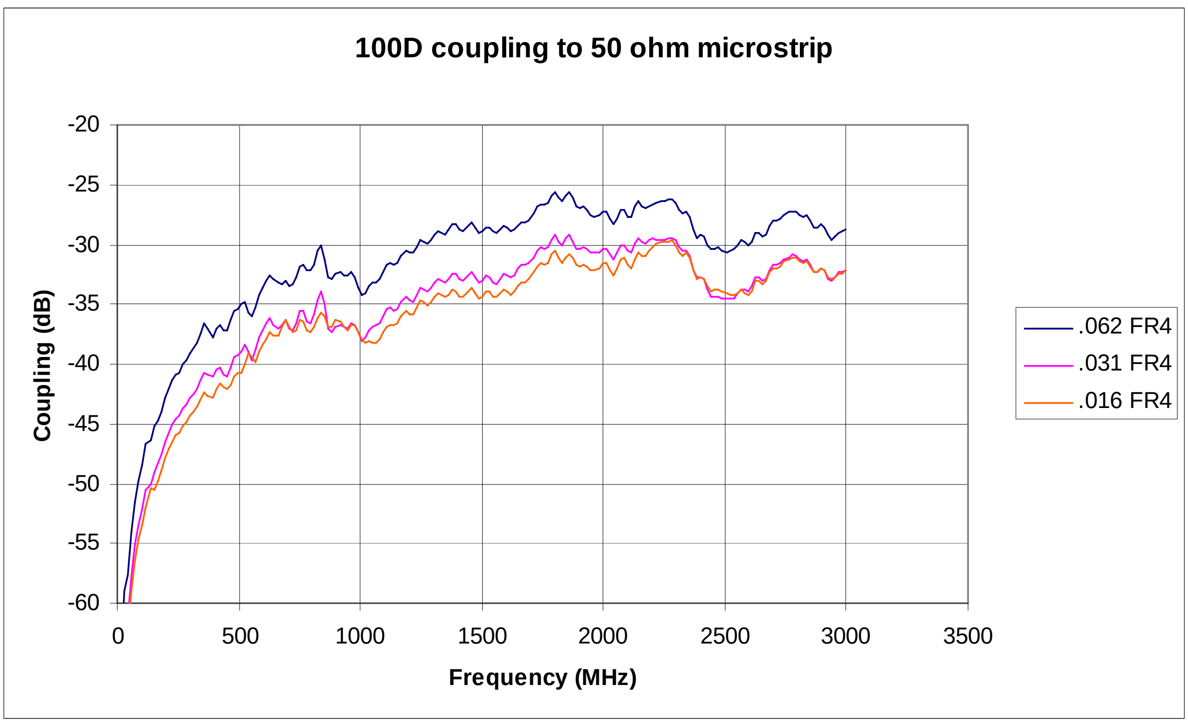
The photo shows a 100A H-field probe measuring the power on the 50 ohm line. Port one of the network analyzer was connected to the test board, and port two of the network analyzer was connected to the probe. Note that, unlike E-field probes, H-field probes are directional. Maximum coupling occurs when the plane of the loop is aligned with the microstrip trace.

Coupling was measured for each probe to transmission lines on each of the three substrates. The results are shown below. Note that the frequency range of the measurements differ for the various probes, depending on the frequency range of the probe itself. The 100C H-field probe has a large loop area, making it most sensitive at low frequencies. However, at higher frequencies the loop reaches resonance, limiting its useful frequency range to a few hundred Megahertz.


100A coupling to 50 ohm microstrip
-20
-25
-30
-35
-40
-45
-50
-55
-60
Coupling (dB)
0
500
1000
1500
2000
2500
Frequency (MHz)
.062 FR4
.031 FR4
.016 FR4


100B coupling to 50 ohm microstrip
-20
-25
-30
-35
-40
-45
-50
-55
-60
Coupling (dB)
0
500
1000
1500
2000
2500
3000
3500
Frequency (MHz)
.062 FR4
.031 FR4
.016 FR4


100C coupling to 50 ohm microstrip
Coupling (dB)
-20
-25
-30
-35
-40
-45
-50
-55
-60
0
50
100
150
200
250
Frequency (MHz)
.062 FR4
.031 FR4
.016 FR4


100D coupling to 50 ohm microstrip
Coupling (dB)
-20
-25
-30
-35
-40
-45
-50
-55
-60
0
500
1000
1500
2000
2500
3000
3500
Frequency (MHz)
.062 FR4
.031 FR4
.016 FR4

An example will illustrate the use of these graphs. Suppose that we want to measure the output power of a 1 GHz oscillator. The oscillator is fabricated on 0.062" FR4 with a bottom-side ground plane. The nominal output power of the oscillator is +10 dBm. What power level would we expect to see?

At 1 GHz, the 100A H-field probe is a good choice. It has an intermediate-sized loop. Being smaller than the 100C, it will be better behaved than the 100C at 1 GHz. Being larger than the 100B, it will have better sensitivity.

From the graphs above, we see that the coupling factor between a 100A probe and 0.062" thick microstrip is approximately -27 dB. So, with a +10 dBm signal, we would expect to measure -17 dBm with a 100A probe.

Sensitivity calculation for phase noise measurements

With adequate sensitivity, it is even possible to make high-dynamic range measurements using non-contact probes. For example, it is possible to use the probes to measure phase noise and spurious on an oscillator.

Suppose we want to measure phase noise at a 10 kHz offset on a 3 GHz oscillator using a spectrum analyzer. The phase noise of the oscillator is approximately -80 dBc/Hz at that offset. Will we be able to make the measurement? Will the phase noise sidebands be high enough in power that we will be able to distinguish them from the spectrum analyzer noise floor?

The following table shows the calculations involved.

Frequency	3 GHz
Oscillator power	+10 dBm
Phase noise target	-80 dBc/Hz
100B coupling factor	-35 dB
Spectrum analyzer noise figure	30 dB
Spectrum analyzer noise floor	-144 dBm/Hz
Oscillator power at probe output	-25 dBm
Phase noise sideband power	-105 dBm/Hz
Measurement noise margin	39 dB

Using a 100B probe at 3 GHz, the probe output power will be -25 dBm with an oscillator power of +10 dBm, assuming an 0.062” FR4 substrate. With a phase noise sideband of -80 dBc/Hz, the output power of the sideband will be -25 – 80 = -105 dBm/Hz. If the spectrum analyzer has a noise figure of 30 dB, its noise floor will be 30-174=-144 dBm/Hz. This shows that the measured signal will be 39 dB above the spectrum analyzer noise floor, which is plenty of margin for the measurement.

If we were to place a preamplifier between the probe and the spectrum analyzer, the effective spectrum analyzer noise figure might be reduced to 10 dB, yielding a noise floor of -164 dBm/Hz. With the preamp in place, we can now measure extremely low phase noise sidebands. For example, phase noise sidebands at -119 dBc/Hz would still be 20 dB below the noise floor of the preamp/spectrum analyzer combination.

Again, note the simplicity of these measurements. No soldering, fixturing, or special design features have been added to the circuit under test. The probe is simply held next to the trace, and the measurement is made. Since the probe tip is nonconductive, there is no chance of accidental shorts, even on a densely-packed board.

Conclusions

Non-contact probes offer a rapid and accurate method for measuring signals on RF PCBs. With no special fixturing, they can be rapidly used to trace a signal path and find a defective component. Using the graphs provided in this article, absolute as well as relative power measurements can be made with ease. Furthermore, the sensitivity of the probes is sufficient to make even high-dynamic-range measurements such as phase noise. All this can be done with no special measurement setups or preparation, allowing rapid measurements in both lab and production environments.

Volt Tattler

The Volt Tattler 2 is a microcontroller based D.C. system voltage monitor with programmable voltage thresholds to monitor and warn of power system problems. This simple but very useful kit is ideal as a novice construction project and every home and portable station should have one.

Specifications:

- Simple through-hole construction
- Draws only around 1 mA in normal use.
- Reverse polarity protection.
- Thresholds programmable over a range of 4V to over 27V.
- Single button programming with audio feedback.
- Audibly announces activation at power on and indicates it is monitoring with a flashing green LED.
- Audibly announces by Morse code when input voltage exceeds user programmed thresholds.
- Flashing Red and Yellow LEDs indicate that a voltage limit has been exceeded.
- 3V digital status signals are available on a header
- Cheap protection for all low voltage DC equipment.

Supporting Files and Documents

[Volt Tattler Owners Manual v2.00](#)

Ordering Information

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Wall Wart Tamer V2

Description

The Wall Wart Tamer lets you utilize those surplus computer and wall pack power supplies as a adjustable sources of clean DC power for radios and equipment.

The Wall Wart Tamer is a simple device designed to filter input power and remove most of the receiver "hash" noise that results from common wall warts and laptop supplies, especially switching supply types.

The project itself is straightforward and if you follow the steps you will have a working Wall Wart Tamer module putting out CLEAN DC power when you finish.

Features

- Takes in AC or DC and provides clean, adjustable DC output
- Reuse those surplus wall warts or computer supplies as DC power sources
- Bridge rectifier, Capacitive filtering and LM317 Adjustable Regulator
- Recommended Input voltage range of 5-25 Volts
- Output adjustable from 1.25V to approximately 3V below the input voltage
- Supplies up to 1.5A current
- Board size of 2.3" x 4.3"

Supporting Files and Documents

[Wall Wart Assembly Manual V2 (5/15/2017)]

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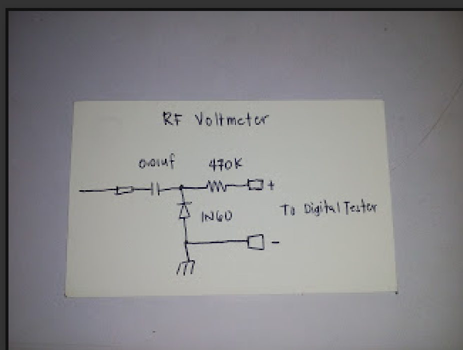
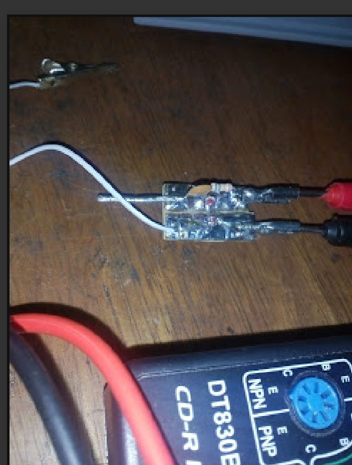
Tuesday, April 5, 2016

QRP RF Voltmeter from your Junk Box

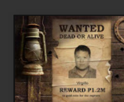


One of the useful tool that you can make out from your junk box is this rf voltmeter. I found this circuit from the internet and make a prototype out of it which turns out a very handy tool in determining the rms voltage in my hf /vhf projects. I use it to determine the output power of my rf amplifier, setting the null in my balanced modulator, determining the peak voltage output of my oscillator, peaking a band pass filter, etc... It takes only 3 components to start with. I use 1N60 germanium diode to rectify the high frequency AC signal into dc voltage readily compatible with any digital multimeter. The diode exhibits 0.3V of forward bias voltage as measured by my digital multi meter. My prototype rf voltmeter is contained in a small pc board assembled in surface mount fashioned. Two connectors soldered on the edge of the pc board to accommodate the positive and negative probe of my digital multimeter.



The alligator clip must be connected to the common ground of the circuit that you are measuring. Avoid using extra length on the alligator wire since this will introduce error in your measurements specially on higher hf bands. In my prototype the alligator clip lead wire is just over 6 inches.

About Me



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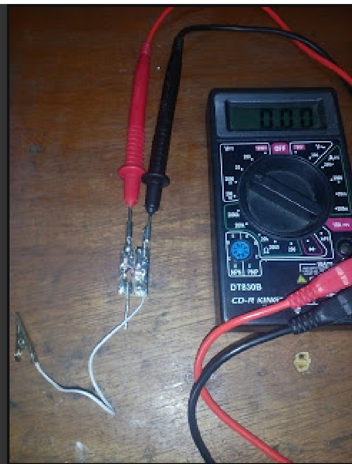

To determine the Vrms reading, don't forget to include the forward bias voltage of the diode that you are using to the voltage reading indicated by your digital multimeter. One example measurement that I take using this rf voltmeter is the power output of my home made dsb transceiver. The reading is taken across a 50 ohm dummy load and the rf voltmeter just reads over 13volts during peak modulation. From the basic power formula P=(Vdmm+Vdiode bias)squared/R(50ohm), the computed power output of my dsb transceiver is just around 3.537watts which is very close to the readings indicated by my Diamond SX200 power meter. ---73 de du1vss

Posted by hevirred at 6:11 AM

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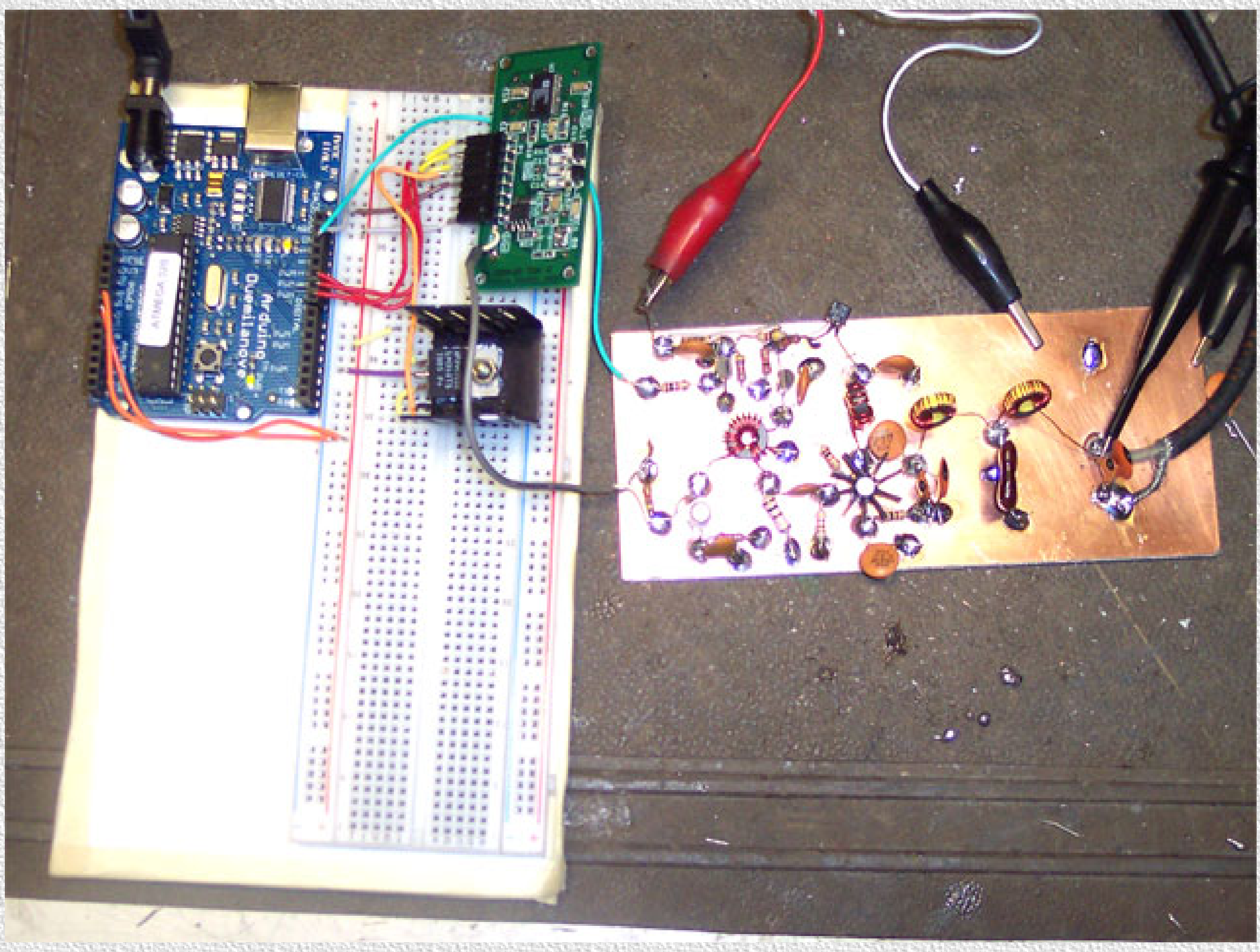
MODEL 3 MEPT



**The above picture is the experimental build of what I am going to call a Model 3 MEPT.
It is an American QRP Club DDS-60 card being controlled by an Ardunio Processor. The 5VDC Regulator was removed from the DDS-60 card to improve the frequency stablility. The external 5VDC Voltage regulator you see on the plug board is now doing it's job. The transmitter card is a two stage 2N2222 transistor buffer amplifier stage and final amplifier with an output filter. It's design is similar to many of the designs found on various QRSS websites. This particular transmitter section is presently setup for 40 meters where I tested it first. The Ardunio Software is still under development but in preliminary testing, worked very well. It controls the frequency of transmission of the DDS-60 card and the PTT keying of the transmitter. Right now the modes that we have working are CW, DFCW, and FSKCW. Work is progressing on incorporating Helschriber. Work is also progressing to provide both a fast CW ID and an Interval transmitting timer so that it doesn't have to transmit continously on the programed frequency. The group that I am part of has made great strides to get this far and hope to get the other portions of the software done soon. Stay tuned for future developements. On my first test on 40 meters I was copied by VK7ZL and ZL2KI running only 160mW. Absolutely AMAZING.**

back to MEPT Transmitter page

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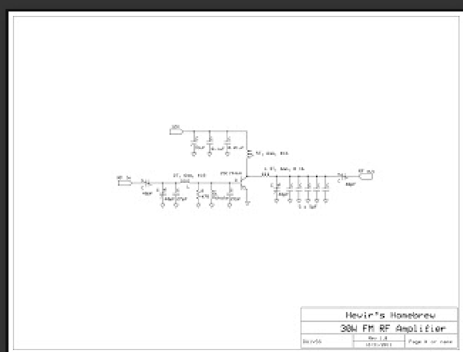
Wednesday, July 20, 2011

Homebrew 30W FM Broadcast Amplifier



The original diagram was taken from the data sheet of Mitsubishi 2SC1946A designed to operate at 175MHz. Both input and output tuning network was modified to work between 88 to 108MHz very well intended for our main purpose. Large heat sink is required since the 2SC1946A must operate at 100% duty cycle. Forced air cooling aids in dissipating the heat produced by the rf transistor. The use of high voltage trimmer capacitor is a must and the use of ground plane technique is best suited for this project. RF input of 1 to 2 watts coming out from the exciter is enough to drive this amplifier to produce 20 to 25 watts of rf output assuming that the DC supply

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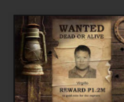

hevirred

Ham since 2000.

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is at 12 volts. Take note that this rf amplifier is operated in class C therefore, the need for low pass filter in the output must be installed to avoid interference caused by the harmonics generated by this amplifier. --- 73 de hevir

Posted by hevirred at 12:09 AM

2 comments:

- **scott hunter** October 18, 2011 at 4:11 AM

  hello mate is there a pcb lay out of this board? and a components list showing where there would be soldierd if so could you email me at scotthntr441@gmail.com cheers 73s

  Reply

- **Kabayan Action Group** March 25, 2012 at 5:24 PM

  Hello sir good morning. May PCB lay out kaba nito at ang nasa diagram ba na mga pesa ito ba yon lahat? Pwidi mo ba ako ma shareran nito gamitin ko lang kc ito sa aming church. Kung pwidi mo ako bigyan ng PCB lay out ito po ang email ko. judy_estella@yahoo.com. Maraming Salamat po

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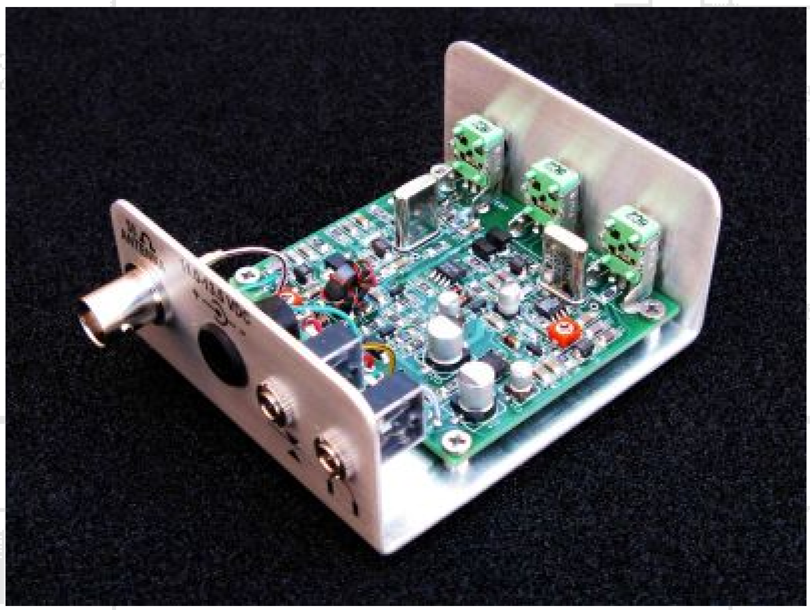
SMK-2 40m Surface Mount CW Transceiver



The SMK-2 is a fully functional surface mount component 40 meter transceiver. It has an independently tuned transmitter and direct conversion receiver. Full break-in TX with sidetone, and a modest 350mW output. The crystal VXO on receiver allow about 3 kHz+ tuning range on the crystal frequency. It was originally conceived as the SMK-1, a platform to teach SMT construction techniques, and to prove how easily a working transceiver was possible, but quickly gained attention as viable tool to test your low power skills to obtain WAS, as has been done by amatures when it was first introduced.

Manuals and other useful information

SMK-2 Construction Manual 1.9

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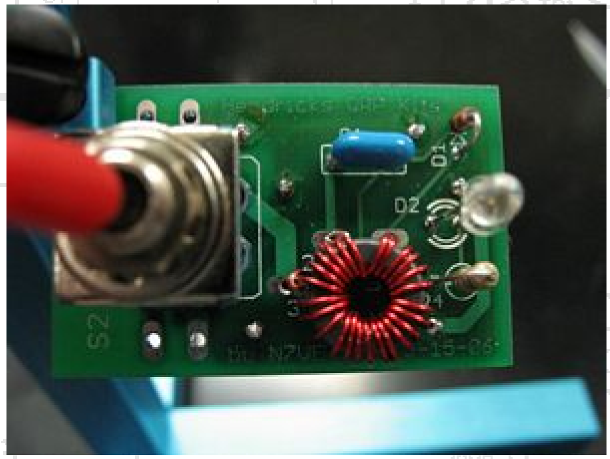
SWR Indicator/Bridge Kit



This kit will enable you to always know if your rig is matched to the antenna. The neat thing is that it also has a built in bridge that you can use to tune up and not harm your finals. This kit is ideal for building into a rig, or you can build it stand alone in a small box. There are only 2 connections to make, transmitter and antenna. To operate, switch the bridge in, tune your antenna tuner until the LED goes out or dims, then switch to operate and you are ready to transmit.

Manuals and other useful information

SWR Indicator/Bridge Builders Manual (ver 3)

SWR Indicator/Bridge Schmatic

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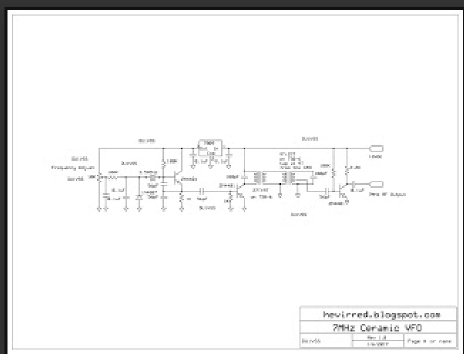
Sunday, December 18, 2016

7MHz VFO using 3.58MHz Ceramic Resonator



This project is a 7MHz vfo that uses a 3.58MHz ceramic resonator. The oscillator output is fed to a frequency doubler but the output of the stage contains full of harmonics. To clean the output waveform, a double tuned band pass filter is added. Each filter resonates at 7MHz and the passband is quite sharp which effectively attenuate the unwanted harmonics.

The output level is at 3volts peak to peak and has a 60Hz per hour drift after some warm-up. Using 1N4007 as varactor, i was able to tune +/- 0.200MHz from the center frequency of the oscillator.   73 de du1vss

Posted by hevirred at 4:31 AM

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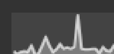

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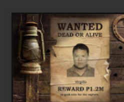

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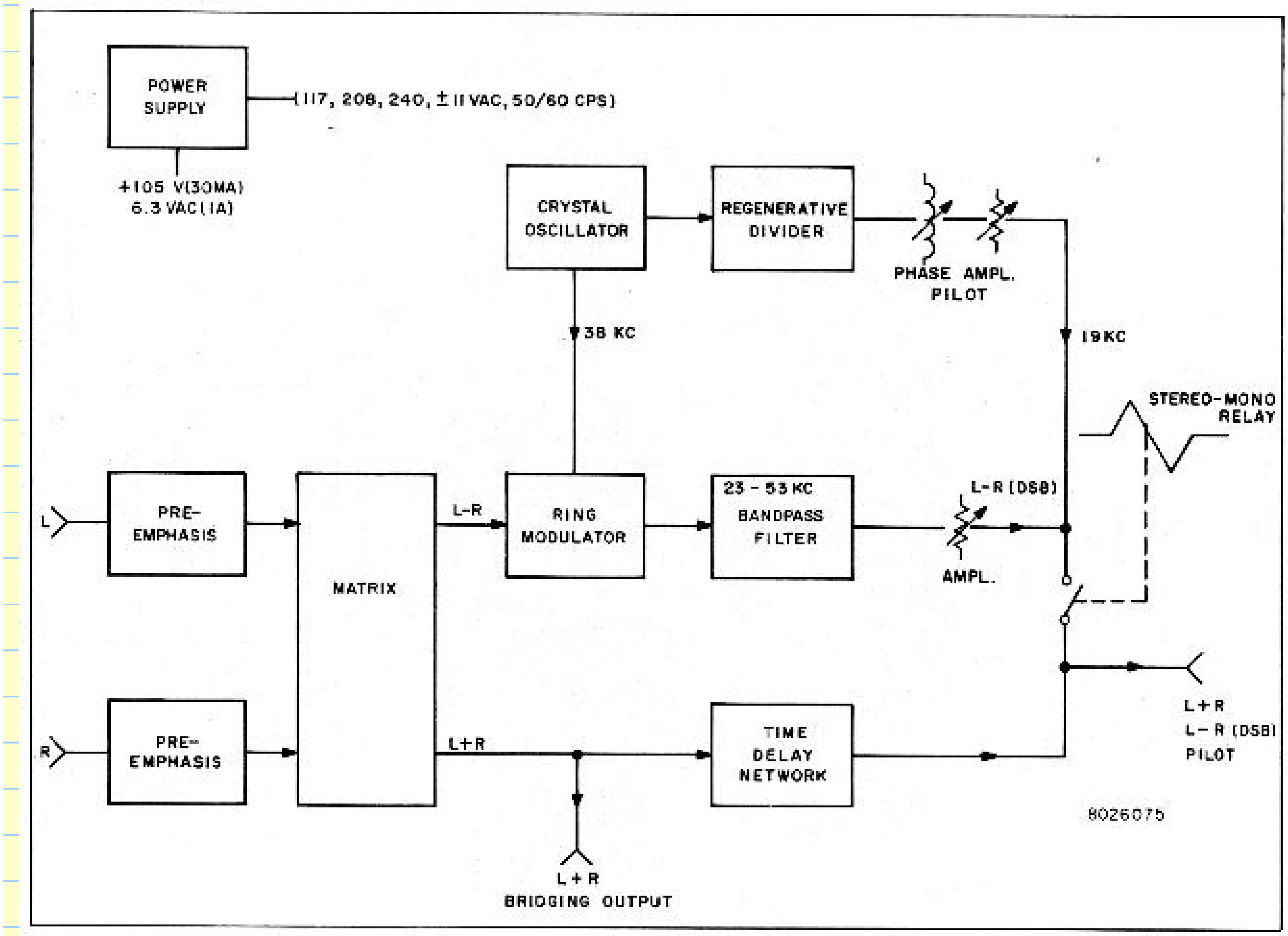
The RCA BTS-1A
World's First Broadcast FM Stereo Generator

This is a picture of the RCA BTS-1A Broadcast FM Stereo Generator. The BTS-1A was the first production FM Stereo Generator to become available after FM stereo was authorized by the FCC in 1961. The BTS-1A was a simple, elegant design, using only two tubes. The Gates model M-6146, a popular Stereo Generator of the time, required a total of eleven tubes to do the same job.



Here is the block diagram of the BTS-1A. For those of a technical bent, who wish to understand the operation of the BTS-1A, please note that the block labeled "Time Delay Network", is actually a 15 kHz lowpass filter, designed so its time delay matches that of the "23 -53 kc Bandpass Filter" at the corresponding subcarrier sideband frequencies. Click here to see the full **BTS-1A schematic**, excepting the details of the filters.

9/15/02

John's Home Page

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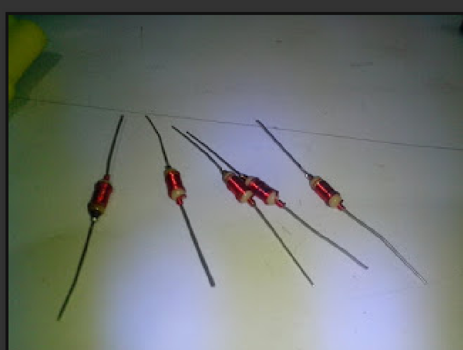
Tuesday, December 22, 2015

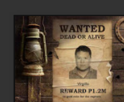
VHF RF Choke

Home made VHF rf choke. It has a typical value of 0.3uH made by winding 15 turns of 0.2mm enamel wire over a high value resistor (27K 1/2watt) as a former. Inductor leads are soldered across the resistor leads and the instant glue secure the winding on the former.



Most of my home made vhf rf amplifiers uses this rf choke in its bias and also in the DC supply section. Commercial vhf choke generally comes in a small package suitably for smd but since I have so many enamel wires in my junk box, home brew comes in handy. ---73 de du1vss

About Me



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Build Your Own Receiver

The **advantages** of making your own Receiver, or other equipment.

eg. Aerials[1], test equipment, auxilleries, synthesisers, etc.

1. The satisfaction of doing it yourself, see what others[2] have done.
2. You get exactly the features you choose.
3. You can change your mind.
   You know what is there, and can add or change at any time.
4. You can gradually add bands & features, according to time, money & understanding.
5. You can get very high performance.
6. You needn't spend a large amount of money.
7. You may need to spend a large amount of time (learning), share this with others.
8. You will gain from this a great deal of knowledge & expertise.
9. You can build separate single band, single mode receivers, as continuous band monitors.
10. You can make it a transceiver if you wish.
11. You can be creative, try your own ways of doing things, as you learn how.
12. You can use a great deal of second hand parts.
13. You can use the classical superhetrodyne[3], or a Software Defined Radio[4] approach.
14. You can choose to use one aerial connector, or group bands between several connectors.
15. You can build your own dial, or use a computer to produce dial like features.
16. You can learn to develop your own computer control programs, lots are doing this.
17. Because of computer simulation, this process is getting simpler, almost no "trial & error".
18. Power supply can be from dry batteries, 12 or 24v DC, mains, internal or external.

Are there any reasons above why you should have a go at rolling your own?

The **disadvantages** of making your own Receiver, or other equipment.

1. I don't know enough to decide what to do.
   Join up with at least one other, and share the learning by discussion.
   A first class reason to join an amateur radio club, in person or via the internet.
2. I don't have enough construction experience. Start with a simple project.
   This will never come by talking without having a go. There are many experienced people ready to help & encourage.
3. I don't have any test equipment.
   There will be people about, or clubs, that do have, can help, in many ways.
4. I don't have enough time.
   Ahh! Then you aren't really interested, go buy something second rate.
   But you can still read and learn, until such time as you re-arrange your priorities to give you some construction time.

Desirable **Features** for a receiver.

1c. Selectivity is the ability to restrict what you hear to a particular range of frequencies, and not hear a strong signal a little off frequency, say on an adjacent channel, being FM, AM, SSB, CW, or a digital mode. With a superhet, often achieved by the use of a crystal filter of the required bandwidth, in the above cases, usually separate filters switched in according to the mode. With an SDR, defined by software thay you can download or write yourself.

2c. Stability is the ability to be able to set the frequency of the desired signal, and know that a short or long time later it will still be precisely on that frequency. SSB requires tuning to stay within about 20Hz, whereas FM may be within about 200Hz. There should be no noticeable frequency shift with temperature, power supply voltage, or mechanical vibration.

3c. Phase noise[5] is the local oscillator noise sidebands that can contribute to interfering noise on weak signals, when a strong adjacent signal is mixed with it. Some lower cost rigs have this design flaw, so are very bad in this respect. Especially 2 metre rigs interfered with by pager systems. The interfering transmitter might also have poor phase noise, which you can't control.

4c. Spurious signal response is the embarrassing ability some receivers have, to pick up signals that they are not intentionally tuned to, and is a design flaw that many lower cost, and older rigs exhibit. Two of the most obvious of these are the image freq (see 7c below) and the harmonics of the oscillator frequency. A poorly chosen oscillator can also produce various spurious frequencies, such as a DDS[6], Direct Digital Synthesiser, if there is truncation of the digital word length.

5c. Third order intermodulation distortion[7] (IP3) is often talked about, but is very difficult to measure on the test bench, but is another feature that can seriously limit the ability of a receiver to hear weak signals when strong signals are on adjacent channels. When choosing circuits, a transistor mixer might have an IP3 figure of -12dbm, whereas a diode ring mixer might be +35dbm or more, ie. 47db better. A very large difference. IP3 is actually the generation of in band spurious signals from an out of band signal, by the non-linearity (intermodulation distortion) of an amplifier or mixer, so it can't be filtered out.

6c. Noise figure[8] is a measure of how much noise the actual receiver produces, which competes with the signals you want to hear, and the smaller the noise figure the better. Where ever possible, the noise coming in from the aerial, with the signal, should be the limiting factor, not the noise generated within the receiver itself.

7c. Image response is one of the worst of the spurious signal responses mentioned in 4c above. The superhet receiver has an input signal frequency, say 53Mhz, and may have an Intermediate Frequency of 10.7Mhz, with an oscillator frequency of 53 – 10.7 = 42.3 Mhz which may be derived from a crystal oscillator at a lower frequency, say 21.5Mhz. Now that osc freq and IF freq will also respond to a signal frequency of 42.3 Mhz – 10.7 Mhz = 31.6 Mhz. Which is twice the IF freq (21.4 Mhz) below the desired freq. Filters should reduce the response at the image freq by about 90db or more.

8c. Dynamic range[9], is a measure of a radio's ability to deal with the very weakest to the very strongest signals without ill effects such as distortion. This term includes 3c, 5c, and 6c above.

Find a **starting point.**
Every receiver has to select a frequency or band of frequencies to listen to.
Lets assume that you have a surplus FM two way radio from a taxi or ambulance etc.
To make this listen on 10, 6, or 2 metres, with a better performance than the original, a new “front end” can be made. This process is exactly the same as if you are making the whole receiver from scratch, a multi-band receiver, or a transceiver. However in this case the choice of the IF frequency has already been made for us, its 10.7 Mhz. Another choice I have deliberately taken is to have the input and output impedance of the filters, RF amplifier and mixer set to 50ohms, to simplify testing each module separately.

Signal Filters
Older receivers had 3 gang tuning capacitors (even older ones had separate tuning knobs for each of three or more tuning capacitors), one gang tuned the oscillator, to set the received frequency (sum or difference between the signal and intermediate frequency), and the other two tuned to the incoming signal, but the ability to deal with Feature 4c above was poor.

We will look at using filters designed for the band required, and using 8 tuned circuits to get very good spurious signal rejection. Looking around the various parts suppliers, we find that shielded variable inductors are more than a dollar each, so 3 filters for the 3 FM bands suggested would cost around $35 just for the inductors. So lets try hand wound inductors, with or without trimming capacitors, as ELSIE enables us to calculate size of wound inductors.

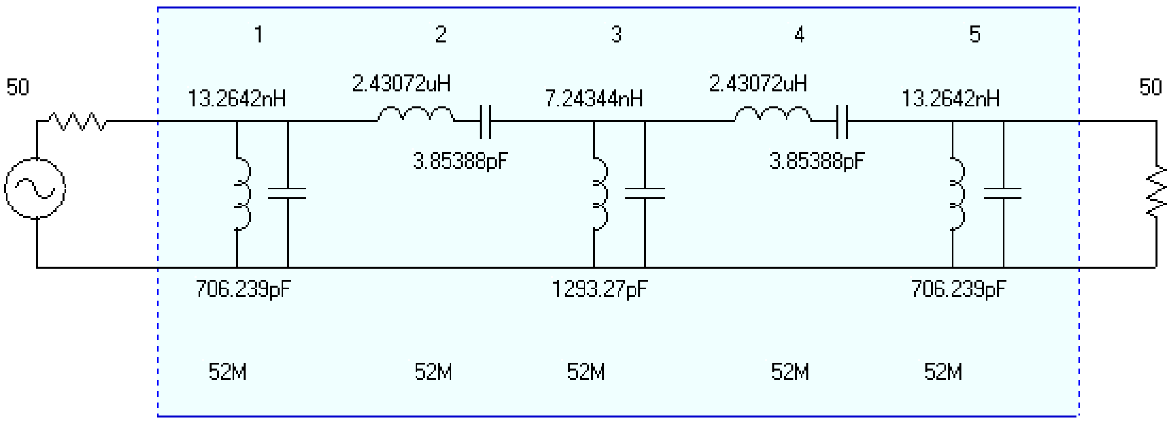
Good news is that Hy-Q[10] has small trimming capacitors in quantities of 100 are only 23c (Aus) each, a more attractive approach, especially for a group construction project. Other suppliers, such as Mouser have similar items. Lets now do some computer calculations and see what can be achieved.

There are a number of different types of filters that can be used as signal filters, and the decision which one to use, varies according to the bandwidth, available components, ease of construction, and cost. Commercial manufacturers usually use a number of tuned circuits, inductively coupled, or else coupled with small coupling capacitors. It is tedious to set inductive coupling up, because there will need be an adjustment of the spacing between the coils. Capacitive coupling can result in very small values of capacitance, and less "high side" attenuation.

If you don't already have the filter design programme, ELSIE, then download the free student version from LINKS 9.4, and start with the two parts of the 6 metre filter. I have chosen a filter with the following :

topology	shunt input bandpass	
family	Chebyshev	
bandwidth	4.5Mhz	(a little wider than the 6m band)
order	3 and then 5	(number of tuned circuits)
input term	50 ohms	(impedance)
passband ripple	.05	(keeps VSWR below 1.2:1)
centre frequency	52Mhz	(centre of 6m band)

To use ELSIE, you click on Design to enter the data, or open the stored file, then you can click on the schematic to see the component values on the circuit.

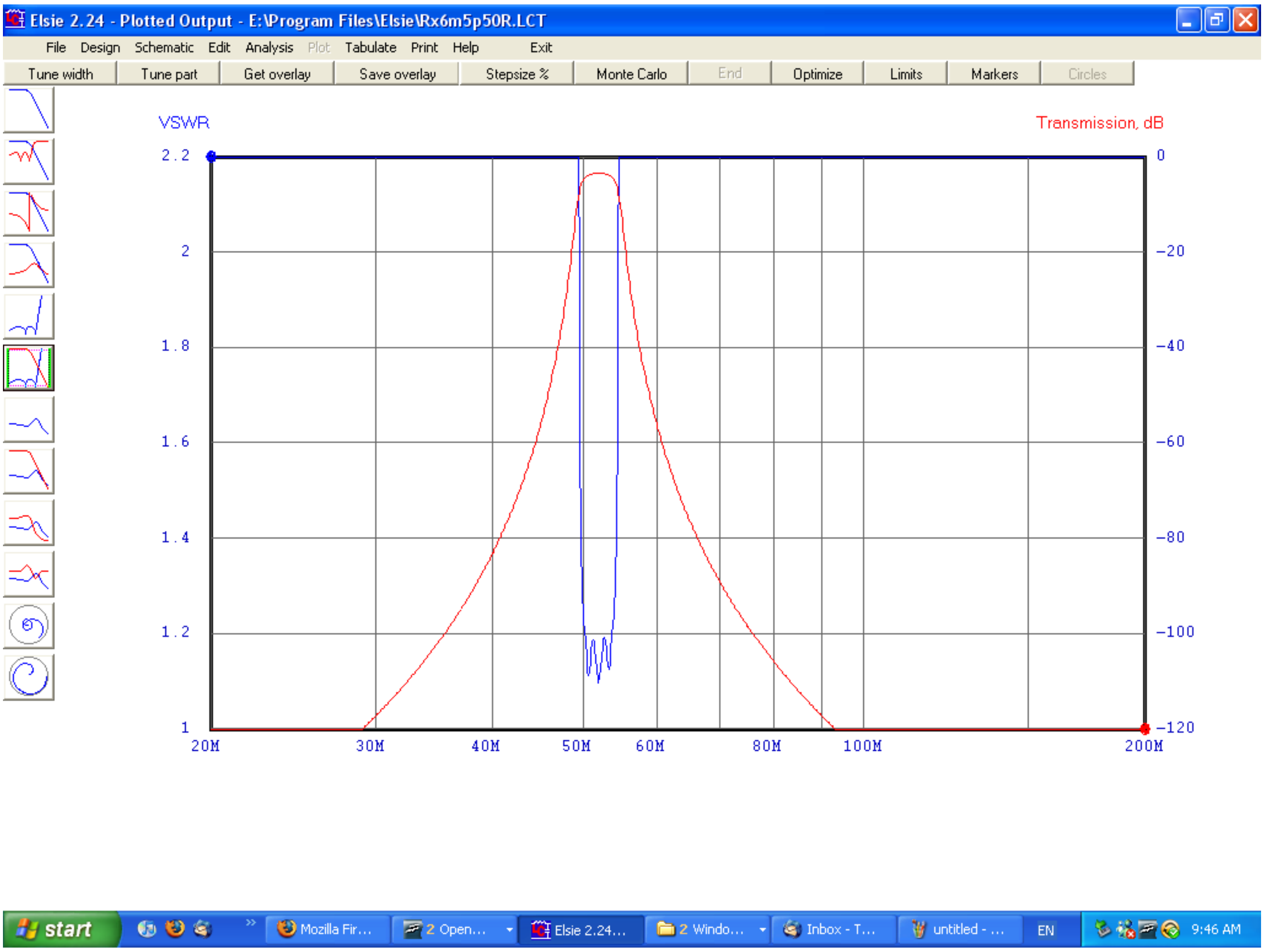


Next click on Analysis and set Start Frequency say 20Mhz, Stop Frequency 100Mhz, Loss Bottom db -120, and the defaults should be ok for the rest. It is most important that you use the upper case "M" after any frequency, otherwise you get really strange results. Then you can click on Plot, to see a range of things, I generally click on the 6th down from the top of the 12 choices on the left. You then get the frequency response in red and the VSWR in blue, see page 4.

You will find that the narrower the bandwidth as a percentage of the centre frequency, the higher will be the loss, or attenuation, for the signals you want to pass. You have some control over this by adjusting the pass band ripple figure, the order (number of tuned circuits or poles[11]) and the Q of the inductors. The

figures shown are a reasonable compromise. All engineering like this is a matter of choosing the best compromises.

The idea is to have the 3 pole filter, with the lower loss ahead of the RF amplifier, so as to not degrade the noise factor by more than 1.5db, and the 5 pole filter after the RF amplifier, but overall attenuation at the image frequency adds up to be well over 100db, a very good figure, even if the shielding is not perfect. In actual fact, two 3 pole filters would probably be adequate (about 110db), but I've decided to "over design" a little, where it doesn't degrade something else. After all, the VHF band is filled up with TV, FM, two way radio, navigation beacons etc. none of which we want to hear.



The component values for the series circuits are sensible for the 50 ohm filter, but the shunt elements of 620pF and 15nH are not. At this frequency of 52Mhz, these components have a reactance of 5 ohms, and this is so low as to be hard to make and very lossy. So what to do? I tried multiplying the impedance by different factors of voltage or turns ratio, the impedance ratio being the square on this, and came up with voltage or turns ratio of 7, so impedance ratio of 49.

What this means is we multiply the inductors by 49, and divide the capacitors by 49, and then put a 7:1 tap to connect to our 50 ohm filter. Running ELSIE again, but changing the impedance to 2450 ohms gives the same figures for the shunt elements only. The tap can be in the inductors or capacitors. This worked out well for the 10 metre case as well.

Using ELSIE to calculate coil sises is very simple, and it enables the 7:1 turns ratio to be readily maintained. For instance for a 650nH coil, choose 1cm long and 14 turns, so diameter 66.1mm. This allows a 2 turn tap to be the 50ohm point, or else a two turn link for balanced feed to the mixer (single

channel version).

With filters having such a high attenuation "out of band", it will be necessary to construct it with very careful shielding, in fact double shielding of the actual filters. If multi-banding, even more care will be needed to get the full benefit of the filters. The use of double sided printed circuit boards, with one side an earth plane, is important in the shielding process, and there are several ways they can be made, but my preference is to use Olimex[12] in Bulgaria, for good quality and reasonable cost.

Looking at the curve shown above, you see the VSWR figure in blue, is always less than 1.2:1 over the pass band, which is very good. Note the "ripple" in the passband, as determined by the entered figure of 0.05. The in and out of band figures can be read from the curve by using the mouse to put the cursor on the curve, and pressing the the right mouse button.

		order 5		order 3	
See	-3.5db	53Mhz		-1.5db	centre
	-5db	50Mhz	54Mhz	-1.8db	pass bandwidth
	-60db	44	61	-27db	stop band
	-80db	40	66	-37db	
	-100db	35	76	-50db	
	-120db	28	93	-61db	

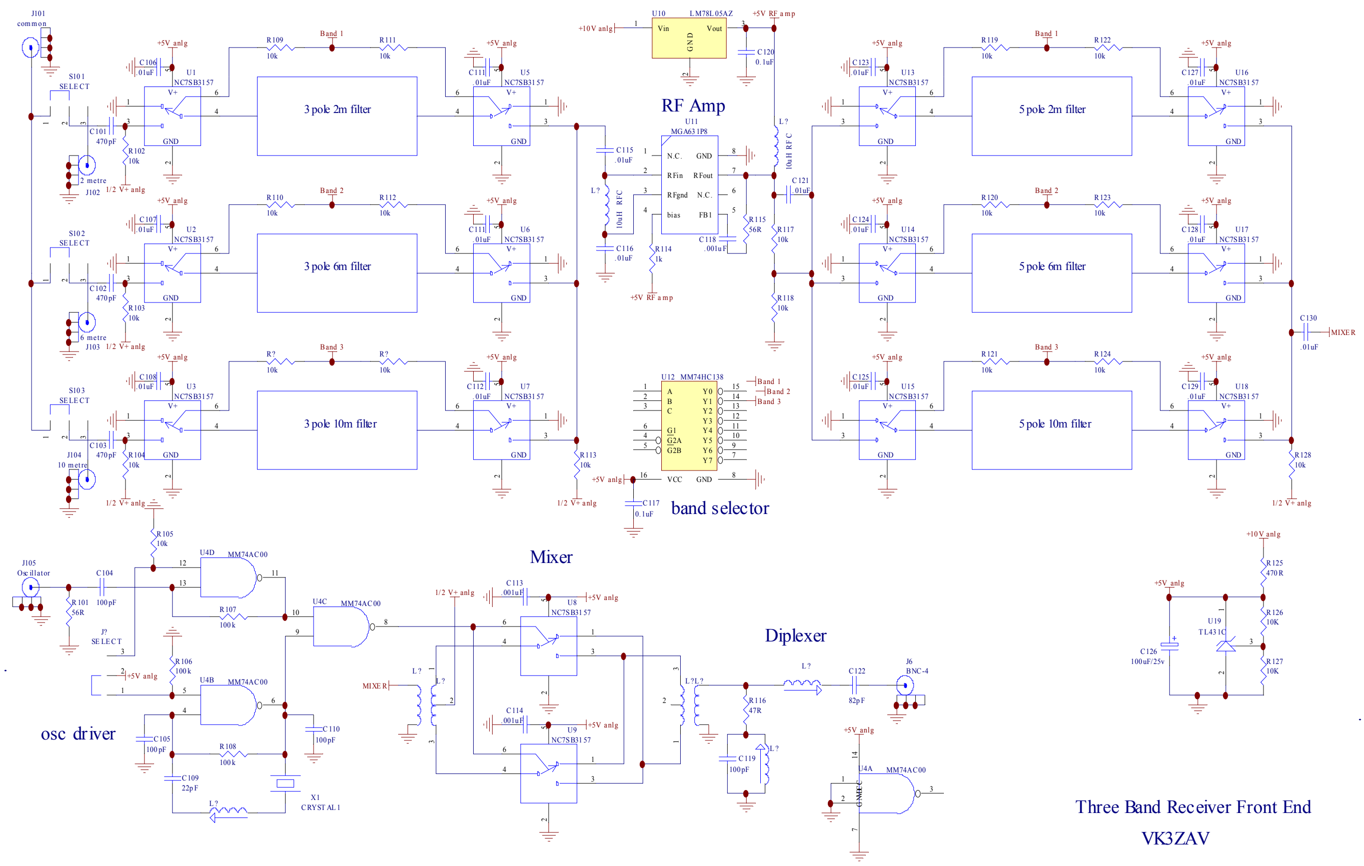
This is a very good performance, and will contribute to a seriously good receiver, without too much cost and complexity. For comparison I have shown the attenuation figures for the 3 pole filter also. Note the attenuation at the Aus. TV Channel 2 (63 to 70Mhz) with 100 kw transmitters, is 70db and 43db for the two filters.

Adjusting these filters requires some thought too, so I will start with the shunt tuned circuits installed on the PCB first, and adjusted independently. Next the series circuits will be installed, and each end bridged to ground, and also adjusted. For the higher bands, choosing 5% surface mount capacitors and adjusting turns spacing to get resonance at the centre frequency as shown on the ELSIE schematic.

RF Amplifier.

There is a common misconception that the noise figure of the RF amplifier for HF receivers does not need to be less than about 10db, but this is not correct. The overall noise figure of the receiver probably does not need to be less than 10db, but if the RF amplifier noise figure is, say 1db, and the input IP3 figure is 20dbm, then you can afford to have another 9db attenuation ahead of the RF amp, yielding an IP3 figure of 29dbm.

For this reason I have chosen a to use an Avago MGA631P8[13] for the RF amp (Mouser[14] $4.68), and expect a noise figure of 0.6db, and an output IP3 of about 39dbm, with a supply of 5v @ 80mA, gain is 16db, so input IP3 = 23dbm. This chip has setable gain and current.
An alternate from Mini Circuits is the GAL-74, with a noise figure of 2.7dbm, output IP3 +38dbm. Fixed gain 25db, too high, so input IP3 = 13dbm, price much the same.



Choosing a Mixer.

The classic approach is to use a packaged mixer, such as a low cost diode ring mixer, with a loss of about 6db, and input IP3 of about 14dbm. In the around $25 class mixers with IP3 of up to 35dbm are available, either diode ring or passive FET. Compare these examples of Mini Circuits[15] LAVI-2VH+, HJK-3H & ADE-1.

I will try a much lower cost approach, that should perform well, using a pair of logic circuits, Fairchild NC7SB3157P6X[16]. This is a CMOS SPDT switch, and can be driven from a logic level signal from a synthesiser acting as local oscillator. Price from Mouser[17] site is $0.30 each. This mixer is yet to be tested here, but should work well for either superhet or SDR receivers. The speed of operation may not be fast enough for 2 metre use, but certainly should be ok for 6 metres.

Another thought is to use 3rd harmonic mixing for 2 metre operation, ie. use the oscillator (square wave) at 1/3 of the frequency. This also reminds us that when using this mixer, the signal filters should have a large attenuation to prevent the mixing of input signals with the oscillator 3rd harmonic.

The IF Filter.

For this example of the FM receiver upgrade, the filter is provided, but if you want to start from scratch, then building your own filter is very much less costly than buying one. There is a low cost source of crystals available in Australia, with a frequency of 11.0592Mhz from X-ON for 36c each, which it seems could make a set of lattice or ladder filters for differing bandwidths. A rough check suggests that a CW ladder filter with bandwidth of 500Hz would use capacitors of about 300pF, an SSB filter with bandwidth of 2.5Khz would use capacitors of about 100pF, and an FM or AM filter with bandwidth of 7.5Khz would use capacitors of about 30pF. I suspect that around 6 to 8 crystals per filter will be needed.

Proper design would require the purchase and measurement of a batch of crystals, and then accurate calculation of capacitors for the bandwidths required. A search of “crystal ladder filter design” using “dogpile.com” (a multi search engine, much better than Google on its own) will find several ways to calculate this, some better than others. The actual IF frequency chosen is not important, unless it leads to a spurious response somewhere. With a digital synthesiser for tuning, it is quite acceptable to use a different IF frequency for each bandwidth, with the control software correcting the tuned frequency.

Multi band operation.

It is possible to switch different front end signal frequency filters to allow one receiver (or transceiver) to operate on different bands, but care is needed, because we have filters with stop band attenuation in excess of 120db, then the switching system will need to have an “off” attenuation of at least this much, quite a tall order. The commonly used method of switching is to use PIN diodes or relays, but meeting the -120db will be quite difficult.

A suggested approach would be to use the same logic switch that I suggested for the mixer, with a separate chip for each end of each band filter, as shown above. This low cost (30c) chip allows the use of a single RF amplifier chip, as its a $5 item, rather than one for each band. The drawback with this chip is that each switch has an on resistance of 6 ohms, so will introduce about 1db of loss, which adds up, but it is still needs a careful look. In this case, the switch is used so as to short circuit the unwanted signal path and get an additional attenuation in the “off” position.

General coverage version.

A variation of the multi-band approach would use a set of filters that each overlap by a small amount, so that computer controlled tuning would select the correct filter for the frequency tuned. This means that each filter would have a bandwidth much greater than a ham bands only receiver, and this might not be as good at rejecting unwanted out of band signals. Have a look at a set of ten filters using a bandwidth of 1.65 : 1, but they might need to be 5 pole and 7 pole.

Lower	centre	upper	bandwidth	
360	470	600	236	Khz
600	770	990	390	
990Khz	1.27Mhz	1.63Mhz	644	
1.63	2.10	2.70	1.062	Mhz
2.70	3.46	4.45	1.752	
4.45	5.70	7.34	2.891	
7.34	9.41	12.11	4.771	
12.11	15.53	19.98	7.872	
19.98	25.62	32.97	12.99	
32.97	42.28	54.40	21.43	

A revolutionary idea is to use a mixture of general coverage and Ham bands only.

Band Switching

There are several approaches to this, from the hand operated mechanical switch of the 1950's, to computer controlled switches of various types. The SDR1000[18] used relays, directly connected to 5 volt logic chips, but this approach can't be recommended for several reasons. I have already mentioned using logic switches, but if we are to produce a design that can be expanded, we have to start with that capability.

Relays seem to be a simple solution, as they are readily obtained and understood. There is an elegant solution to driving then, by using an older logic chip the 74SL145. This is a decoder with 10 open

collector outputs that can switch up to 15v at 80mA. This would allow 12v relays, with reverse diodes across the coils, and can be borne in mind for transmitter or remote aerial matching use. However size, weight, and cost don't favour this option.

The Fairchild logic switch NC7SB3157 has a switching time of a few nanoseconds, needed for the mixer, and on “on” resistance of about 5 ohms, but the shunt capacitance is 18.5pF when closed and 6.5pF when open. This means that for a 10 band switch, you need to cope with 77pF[19], which might just be possible to incorporate into each of the band filters, but is difficult, and prevents adding additional bands as the urge comes on you.

This brings us back to PIN[20] diodes, and we need to select according to the frequency, the “on” resistance, the “open” capacitance, the power level, and the cost. To assess the lowest frequency that is usable, we need to know the minority carrier lifetime (t), and that reflects on the ham bands as follows:

160m	800nS
80m	400nS
40m	200nS
20m	100nS
10m	50nS
2m	10nS

A search through the Digi-Key and Mouser sites show up some low cost candidates, but not usable for all bands. Looking mainly at receiving power levels here,

Maker	type No.	t nS	C pF	R ohms	voltage	$ approx 100+
Infineon	BA592	120	0.6pF	0.35	30v	0.13
Infineon	BAR64	1550	0.23	2.1	150	0.22
Infineon	BAR67	700	0.35	1.0	150	0.38
NXP	BAT18	120	0.75	0.4	35	0.22
ON	MMBV3700	300	0.7	0.7	200	0.22
ON	MMBV3401		1.0	0.7	35	0.15

Most of the diodes shown above are made by several different manufacturers, and all should be interchangeable.

Now the BA592 looks good as long as you are switching at 20 metres or higher frequency, its able to achieve 0.45 ohms with only 2mA of current, really excellent. The rest of the bands should be ok. with the the BAR64, and its loss will still be under 0.5db I have so far been unable to find the minority carrier lifetime figure for the MMBV3401, a chip developed many years ago by the former Motorola Semiconductors. If you use a PIN diode at a lower frequency than recommended, some rectification will take place, giving distortion and intermodulation, so should be avoided.

The 200 volt rating of the MMBV3700 suggests that this chip could be used safely for switching for power levels of 40 or perhaps 50 watts, for the receive side of a transmit receive switch. For the transmit side, a number of, say, 3 or 4 could be used in parallel, providing that the DC current feed is to each diode separately.

an on going project by Peter Ward, VK3ZAV.

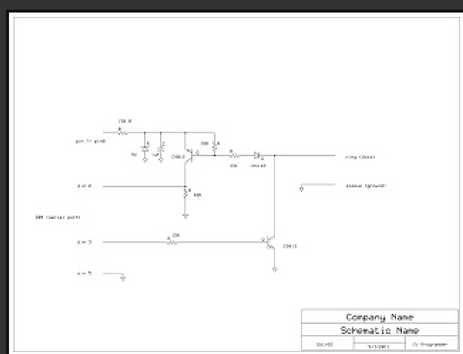
1 I use the English term aerial, whereas some use the biological term antenna, here they are interchangeable.
2 http://yu1lm.qrpradio.com
3 http://en.wikipedia.org/wiki/Superheterodyne_receiver
4 http://en.wikipedia.org/wiki/Software-defined_radio
5 http://www.analog.com/en/technical-library/application-notes/design-center/products/rfif-components/direct-digital-synthesis-dds/resources/index.html get application note AN-741
also http://www.exothink.com/SDR/SDRPN/index.htm
6 http://search.analog.com/search/default.aspx?query=DDS&local=en
see the application notes & data sheets, AN-927
7 http://en.wikipedia.org/wiki/Intermodulation
8 http://www.radio-electronics.com/info/receivers/sensitivity/sensitivity.php
9 http://www.radio-electronics.com/info/receivers/dynamic_range/dynamic_range.php or
http://www.radio-electronics.com/info/receivers/dynamic_range/dynamic_range.php
10 See LINKS 6.11
11 Filter poles, in this type of filter same as thr number of tuned circuits, ie, L C pairs.
12 See Links 7.7
13 http://www.avagotech.com/search/results.jsp?src=&siteCriteria=MGA631P8
14 http://www.mouser.com/Search/Refine.aspx?Keyword=mga631&Ns=P_SField
15 See http://www.minicircuits.com
16 http://www.fairchildsemi.com/sitesearch/fsc.jsp?text=NC7SB3157P6X&as=1&render=1&w=&command=text&attr1=&attr2=&t=0&i=sitemap+id&ia=1
17 see http://au.mouser.com/Search/Refine.aspx?Keyword=NC7SB3157P6X&Ns=P_SField
18 http://www.flex-radio.com/About.aspx?topic=history
19 The sum of 18.5 + 9 x 6.5pF for one switch "on" and switches 9 "off", all in parallel.
20 See http://www.rfdesignline.com/howto/209900491
and http://www.qsl.net/n9zia/wireless/pdf/an922.pdf
also http://www.vishay.com/company/press/releases/2002/021206rfdiodes/

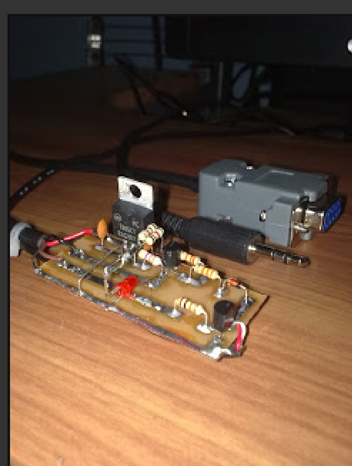
du1vss home brews

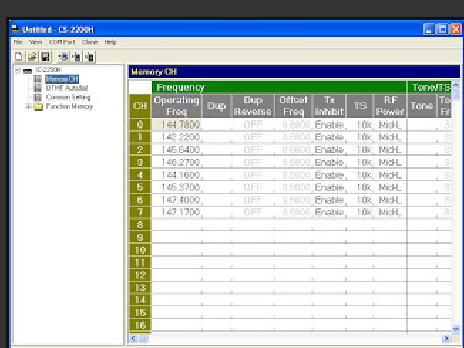
All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Wednesday, June 16, 2010

OPC-478 Cloning Cable







Another evening project is this OPC-478 cloning cable for my Icom IC-2200H. Credit is given to Icom which the original circuit was taken and also to the cloning software (CS-2200H) used on this project. The prototype board supply was taken from the RS232 port of the computer while if this does not work, the 5 volts can be supplied externally. A quick check on the COM port setting

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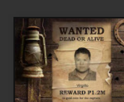

hevirred

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of your PC before running the cloning program will prevent any conflict. If your PC does not have RS232, you can have an RS232-to-USB converter available in computer shops. ---73 de hevir

Posted by hevirred at 6:14 AM

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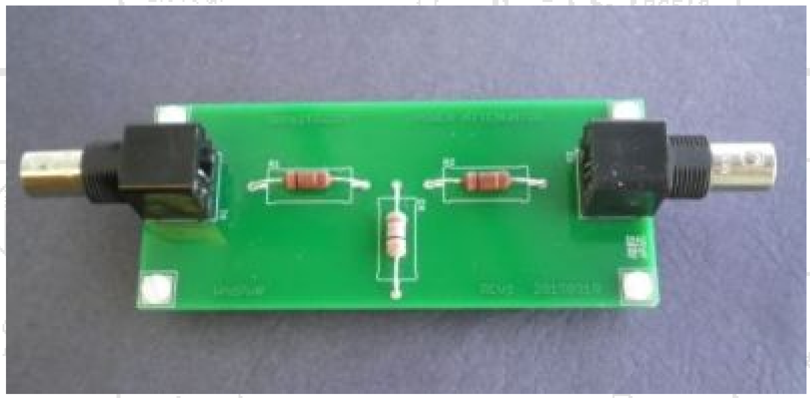

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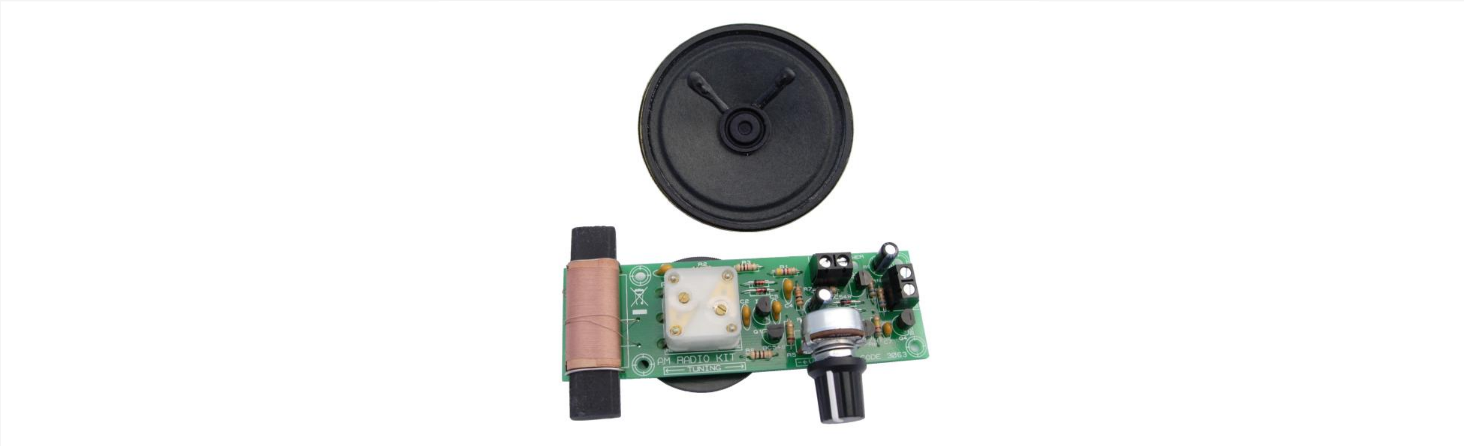

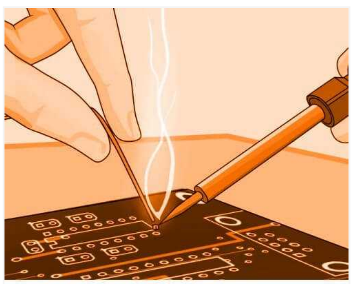

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Board Connections	Screw terminal blocks (speaker and power)
Product Format	SELF-ASSEMBLY Electronic Kit (KT) Product Formats Info
Documentation	User Manual

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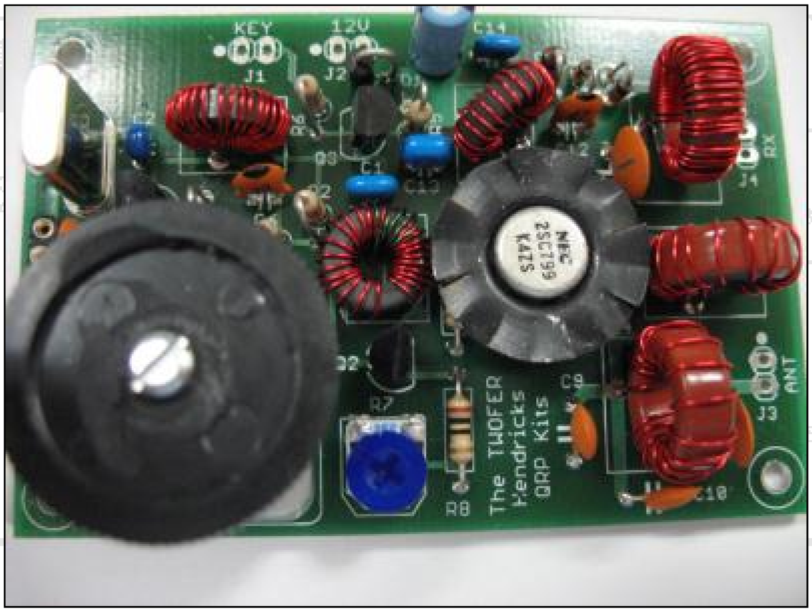
TwoFer Transmitter Kit



The TwoFer was originally designed for the QRP ARCI by John Collins and Mike Michael about 20 years ago. Recently Richard Fisher, KI6SN, revisited the kit and updated it so that it would meet current FCC specs. Rich's version used a no longer produced air variable to tune the VXO. Bob Okas, W3CD and I confirmed that a polyvaricon would work in its place. Bob then designed a board, we tested the prototypes, and now are pleased to offer 40 and 20 meter versions of the kit. The TwoFer uses a 2SC799 or a 2N3553 as a final, and puts out about 2 Watts. It is crystal controlled with a VXO that gives about 1.5 kHz on 40, and about 3kHz on 20M. It also has a T-R switch that mutes the receiver during transmit. It comes with a double sided, plated through, solder masked and silkscreened board, all board mounted parts. and a crystal for either 14.060 or 7.040. It does not come with connectors.

Manuals and other useful information

TwoFer Builders Manual

Back To Top

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Pacific Antenna Return Policy

The Search for Steel Galena

Galena (lead sulfide) is one of the most sensitive minerals for use in crystal radios. Most of the galena I've encountered in rock shops, etc. is the stuff with large crystal structure. However, the galena used in the old days had a much finer crystal structure. It was known as steel galena due to having the appearance of a broken piece of cast iron or steel. It's generally easier to find, and hold, a sensitive spot on this material. There have been some suggestions that this may be argentiferous (silver bearing) galena.

These are vintage detectors, from three different manufacturers, mounted in lead alloy. The mounts are about 0.5" in diameter. I sure wish I could find a pound or two of this material. It would make a lot of detectors. See Mounting Detectors

To: Crystal Sets Top

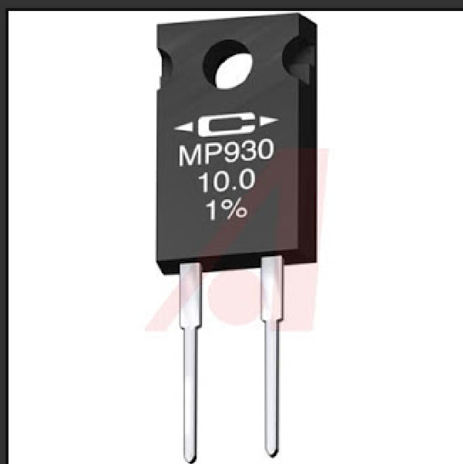
To: Skywaves Home Page

du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Saturday, July 6, 2013

Home Brew 60W RF Dummy Load

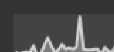


Another great way of making your own 60 watts dummy load is by the use of Caddock thick film power resistor. Purchased some of these at http://philippines.rs-online.com/web/ which cost at 270 Pesos each. Two 100 ohm / 30W resistors were paralleled to make a 50 ohm / 60W dummy load. The good thing about this product is that it comes in TO-220 package and mounting this on a suitable aluminum heat sink is a big help in heat dissipation during actual use. Been able to test my prototype on VHF and provides a very good matched at 144MHz exhibiting an SWR value of 1.1:1 across the amateur band due to the fact that reactive components can be easily minimized because of the unique package of this resistor.

Blog Archive

► 2017 (3)
► 2016 (3)
► 2015 (4)
► 2014 (6)
▼ 2013 (4)
► November (1)
▼ July (2)
Switch Mode Power Supply Unstable Output Cure
Home Brew 60W RF Dummy Load
► June (1)
► 2012 (4)
► 2011 (4)
► 2010 (7)
► 2009 (5)
► 2008 (5)

Total Pageviews



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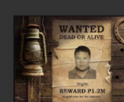

hevirred

Ham since 2000.

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Thermal compound was added between the aluminum surface in contact with the power resistors. A pig tail coax to PL259 connection was also included but a slight increase in SWR was noted. 73 de du1vss

Posted by hevirred at 9:33 PM

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Diodes

Back to the index

Which diode can I use best in my crystal receiver?

Maybe you think a diode with a voltage drop as low as possible, then also small signals at the detector circuit are detected.
But diodes with a low voltage drop, also have a high reverse current (leaking current), this will load the detector circuit heavier, the Q of the detector circuit reduces, and with that also the voltage across the LC circuit.
At a lower input voltage the diode will give much more losses, and it can happen that despite the lower voltage drop of the diode, you have less voltage at the load resistor.
Besides that, reduction of circuit Q will also gives a less selective receiver.

For every 20 mV less voltage drop, the reverse current will approximately double.

Germanium, silicon, en schottky diodes.

Depending on the material they are made from, we can distinguish germanium diodes, silicon diodes and schottky diodes.
There are some more types, which are not discussed here.

Silicon diodes have the highest voltage drop (about 0.5 Volt) and are for this reason not very useable for crystal receivers.
Unless we use a small DC bias current, which brings the diode already a little bit in conduction.

Germanium diodes have a low voltage drop (about 0.1 - 0.2 Volt) and are often used in crystal receivers.
The properties like voltage drop and reverse current can vary a lot between two germanium diodes of the same type.
In practice we can best test several germanium diodes in our receiver and then choose the best.
The diode resistance RD of germanium diodes is most times rather low, and only useable in crystal receivers with a low Q (low sensitivity and low selectivity).
For high performance receivers, we can better use a suitable schottky diode.

Schottky diodes have a voltage drop of about 0.25 Volt.
The differences in properties between two diodes of the same type are often small.
Schottky diodes with the correct resistance RD are very useable in high quality crystal receivers.

The given voltage drop is normally measured at a forward current of about 1 mA.
Also if we measure the voltage drop of a diode with a multimeter, the test current shall be about 1 mA.
But also below this voltage drop the diode can conduct current, and can rectify a RF (radio frequency) signal.
Only the current through the diode is then much smaller.
When receiving very weak stations, the current through the diode can be e.g. only 10 nA.
At such a low current, the voltage drop of the diode is also much lower then at 1 mA.

Detected voltage as function of the input voltage

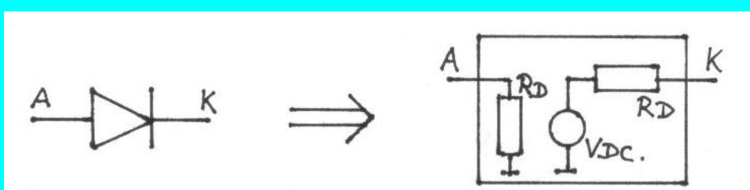
If we rectify a RF signal with a diode we can distinguish two situations.

Situation 1: Rectifying in the linear region
If the input voltage is high enough (well above the voltage drop of the diode at 1 mA), the output voltage of the diode will be about proportional to the input voltage.
So double input voltage, gives about double output voltage.

The output voltage is almost equal to the peak value of the input voltage.
The power losses in the diode are in this region very low compared to the rectified power.

Situation 2: Recifying in the square law region
If the input voltage is low, lower then the voltage drop of the diode (at 1 mA) then the situation is completely different.
The input of the diode behaves for the RF signal like a resistor with value RD.
The output of the diode behaves like a DC voltage source in series with a resistor, the value of this resistor is also equal to RD.
The value of the DC voltage source is square law related to the amplitude of the RF input signal.
So double input voltage, gives 4 times as much detected DC voltage at the output
In the square law region the output voltage of the diode will be much lower then the input voltage, the diode gives much power loss between input and output.
The lower the input voltage, the higher the losses.
The higher the input voltage, the lower the diode losses.
When further increasing the diode input voltage, we gradually come into the linear detection region.
When receiving weak stations, detection takes place in the square law region.

Between the linear and square law region, there is a region not linear, and not square law but somewhere in between.
This region is not discussed here.



Equivalent circuit of a diode at low input voltages.

Via this link you find a measurement on several schottky diodes, which shows detection in the square law region takes place at input voltages below 200 mVpp.

Diode resistance RD.

At zero voltage, diodes have a certain resistance.
This resistance at zero Volt we call RD.
The lower the reverse leaking current of the diode, the higher resistance RD.
When detecting small signals (in the square law region) the input of the diode also behaves like a resistor with value RD.

But how do we know the RD of a diode?
We can calculate it with the formula:
formula 1: **RD = 0.000086171 x n x TK / Is**

RD = diode resistance at zero Volt (unit: Ohm)
n = *ideality factor*, the lower this factor the better, between 1.0 and 1.1 is a very good value.
TK = temperature in Kelvin (= temperature in ºC + 273)
Is = *saturation current* (unit: A)
x = multiply

The values of n and Is can (sometimes) be found in the diode datasheet.

In the following table some types of schottky diodes, with the values for n, Is and Rd, the maximum reverse voltage and the diode capacitance at zero voltage.

type diode	n	Is at 25 ºC	RD at 25 ºC	maximum reverse voltage	capacitance	
5082-2835	1.08	22 nA	1260 kΩ	8 Volt	1 pF	datasheet
BAT85	?	?	± 200 kΩ ??	30 Volt	10 pF	datasheet
HSMS 2820	1.08	22 nA	1260 kΩ	15 Volt	1 pF	datasheet
HSMS 2850	1.06	3000 nA	9.07 kΩ	2 Volt	0.3 pF	datasheet
HSMS 2860	1.10	38 nA	743 kΩ	4 Volt	0.3 pF	datasheet

To decrease the value RD, we can connect more diodes in parallel, with two the same diodes parallel the value of RD shall halve.
With 3 diodes parallel, the value of RD shall be divided by 3 etc..

Diode resistance when using bias current.

We can decrease the value of RD by sending a small DC bias current (e.g. 0.1 uA) in forward direction through the diode.
The higher the bias current, the lower RD will be.
With the following formula we can calculate the diode resistance RD, when we make use of a DC bias current.

Formula 2: **RD = 0.000086171 x n x TK /(Ib + Is)**

RD= diode resistance at certain DC bias current Ib (unit: Ohm)
n= *ideality factor* of the diode
TK = Temperature in Kelvin (= temperature in ºC + 273)
Ib= DC bias current through the diode in A
Is =*saturation current* of the diode in A

A diode with a certain RD value at a certain bias current, gives the same receiving performance as a diode without bias current with the same RD.

Influence of temperature on "saturation current: Is"

The saturation current (Is-value) is strongly depending on temperature.
A temperature increase of 1 ºC will increase the Is value by about 7 %.
In datasheets, the Is value is most times given at 25 ºC.
If the diode temperature is not 25 ºC, but another value "T", then we must multiply Is with a factor 1.07^(T-25).
T = diode temperature
^ = raise to the power of

Ideality factor n

The ideality factor n of a diode indicates how good the diode performs with regard to an ideal diode.
A (not existing) ideal diode has a value of n=1.
At low input signals, the maximum available detected output power is proportional to 1/n.
So doubling the n will halve the output power (this only applies at weak signals).

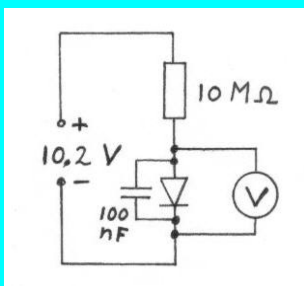
Diode capacitance

Between the two connections of the diode there will be a certain capacitance (capacitor value), when this capacitance is fairly high (e.g. 10 pF) the tuning range at high frequencies is limited.

At increasing reverse voltage across the diode the capacitance will reduce, also the detected voltage in a crystal receiver is such a reverse voltage.
Through this, the frequency of the circuit can shift upwards when receiving strong signals.
On the next page: experiments with a detector unit you find in table 3 a measurement about the frequency shift.

Measuring the Is value of a diode.

We can measure the Is value of a diode as follows:
Send a small current through the diode, the value of this current (I_D) must be about 1 µA.
Measure the voltage across the diode (V_D).



Circuit diagram for measuring the Is value of a diode.
The voltage across the diode is about 0.2 Volt.
The voltage across the resistor is about 10 Volts, so the current is about 1 µA.

The voltmeter must have a resistance of at least 10 MΩ.
The 100 nF capacitor reduces the influence of radio signals and hum on the measurement.

Calculate Is with the formula:

formula 3: **$I_s = I_D / (e^{(V_D/(0.0257 \times n))}-1)$**

Is = *saturation current* of the diode in nA
I_D = current through the diode in nA, (1 µA = 1000 nA)
e = base of the natural logarithms, this is about 2.718
^ = raise to the power of
V_D = voltage across the diode in Volt
n = *ideality factor* of the diode, if you don't know this value, take for instance: n= 1.08

More information about measuring the Is you can find on the website of Ben Tongue , in his articles number 4 and 16.

I measured the Is value of several diodes, and calculated the diode resistance R_D.
Also some European germanium types are measured.
Several diodes are measured of the type OA95 and AA119

Diode	V_D (Volt) at 1 µA	Is (nA)	R_D (kΩ).
HSMS282K	0.1341	7.9	3428
HSMS282K 2 parallel	0.118	14.5	1867
HSMS286K (1 diode)	0.1116	18.3	1479
5082-2800	0.1871	1.14	23756
5082-2835	0.1464	5.04	5373
5082-2835 2 parallel	0.1289	9.5	2850
BAT 82	0.136	7.3	3710
BAT 85	0.0686	90.8	298
OA81 (germanium)	0.0225	800	34

OA95 #1 (germanium)	0.0272	600	45
OA95 #2	0.0221	821	33
OA95 #3	0.0271	604	45
OA95 #4	0.0304	502	54
AA116 (germanium)	0.0441	256	106
AA119 #1 (germanium)	0.0320	461	59
AA119 #2	0.0363	370	73
AA119 #3	0.0428	272	100

The HSMS282K is the same as the HSMS2820, only the HSMS282K has 2 equal diodes in one package.

The Is value of the HSMS282K, the HSMS286K and the 5082-2835 is lower than the value in the datasheet, this has also been noticed by other people.
Ben Tongue wrote me, that the Is value of the 5082-2835 has been reduced over the years by the manufacturer.
Also temperature has big influence, I measured at 18 ºC, in datasheets the Is value is given at 25 °C.
A increase from 18 °C to 25 °C will increase the Is by 60 %.

Back to the index

Temporarily out of Stock
Please check back soon for availability

BitX SSB 17M and 20M Transceiver

The BitX20A and BitX17A are complete SSB kits with board, all parts, digital display and custom powder coated and punched case that is based on the BitX20 that was designed by Ashlan Farhan. The kit includes a commercial quality plated through, silkscreened, solder masked board, and all board mounted parts, plus the polyvaricon tuning capacitor, digital dial, custom powder coated and punched case, knobs and controls. Everything you need to build the kit is provided.

I encourage you to check out the BitX20 users group on Yahoo. They have agreed to provide support for the kits. There are hundreds of messages on there about the history and development of this kit. Our kit puts out about 10 watts, features dual IRF510's as finals in a push-pull arrangement. The schematic is available at the Bitx20 site on Yahoo.

Supporting Files and Documents

Full Bitx20 Assembly Manual

Full Bitx17 Assembly Manual (ver 03/22/09)

[Digital Dial Assembly Manual (Current ver B)]

[BITX20 Build Notes V6]

[Full Bitx20 Assembly Manual Spanish]

[Full Bitx17 Assembly Manual Spanish]

[Assembly instructions for the Bail]

[Bitx20 to BITX17 Conversion Instructions]

Back To Top

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MK484 One Chip Radio

This is the AQA version closing after June 2019. Visit the the version for Eduqas instead.

To gain access to revision questions, please sign up and log in.

Extras: 4026 Counter | Advanced SDR | Class D Amp | Crystal Oscillator | **MK484 Radio** | NOT Gate Astable | QAM | Parallel Port | RF Amp | SA602 Dalek | Sine Oscillator | Tone Control | UHF RX | UHF TX

Non-Exam Extras

The ZN414 is dead - long live the MK484!

The MK484 chip incorporates RF amplification, AM demodulation, AF amplification and automatic gain control (AGC).

- The inductor is 50 to 100 turns of wire on a ferrite rod.
- The variable capacitor has a maximum capacitance of 150pF.
- A long wire antenna can be coupled to the tuned circuit using a single turn coil.

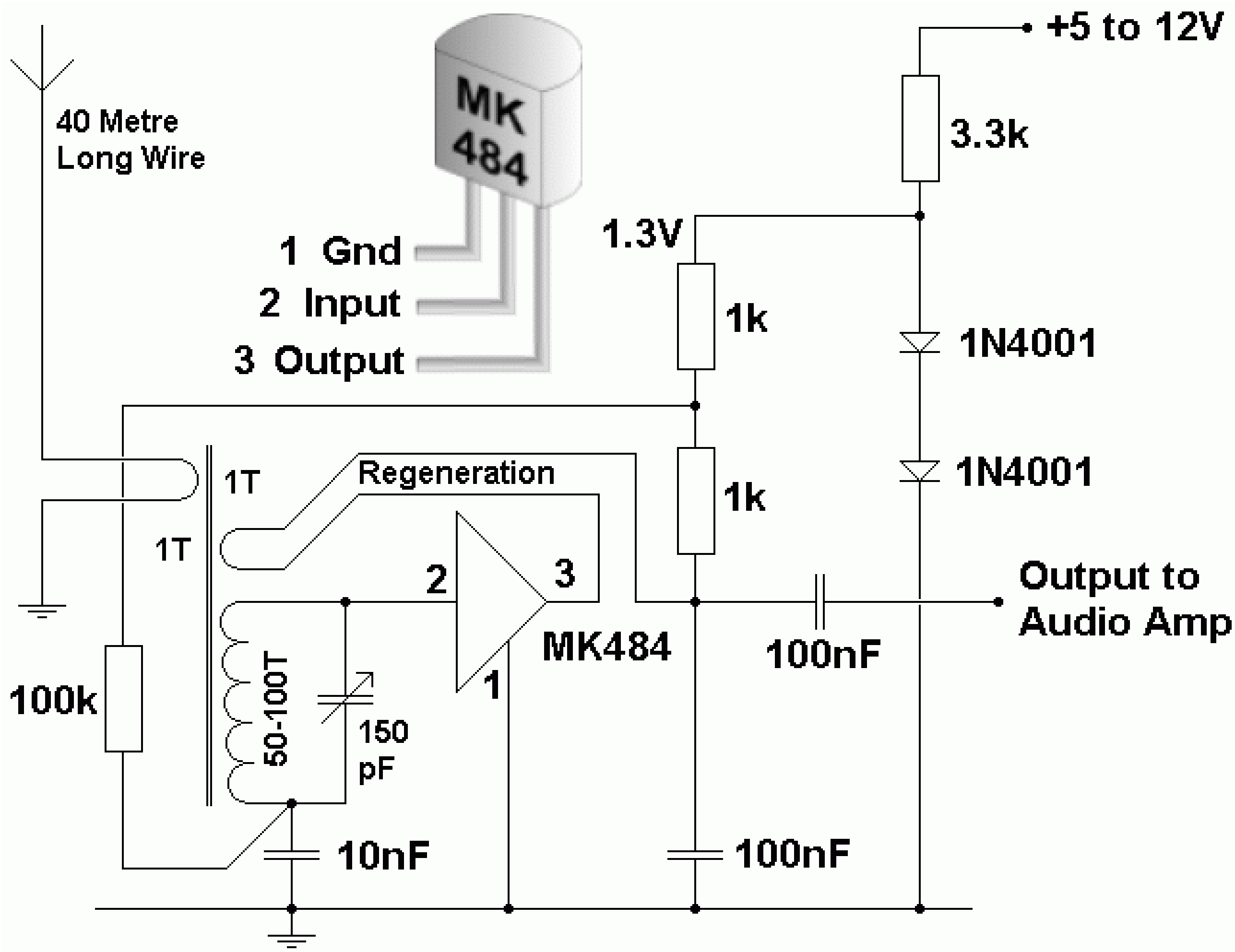
The chip data sheet assumes you will use a 1.5 volt cell to power the radio.

- This circuit assumes you will run it on 5 to 12 volts from a mains power supply.
- The two 1N4001 diodes hold the chip supply to between 1.2 and 1.4 volts.
- Any normal silicon diodes could be substituted here.

This diagram also includes regeneration (not documented in the data sheet). This is positive feedback of the MK484 RF output back to the input. This compensates for energy losses in the ferrite and the tuned circuit. The feedback consists of a longish wire routed near the ferrite rod. (It is a coil with one turn.) The positioning of this wire is critical. If the coil is in the wrong orientation, the feedback will be negative. If there is too much feedback the receiver will become unstable.

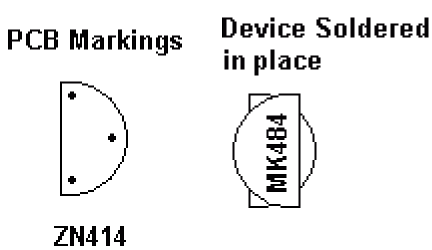
The effect of regeneration is to ...

- feed back energy from the output to the input to compensate for losses in the tuned circuit
- increase the "Q" of the tuned circuit making the receiver more selective
- increase the gain of the receiver making it more sensitive
- if there is too much feedback, the receiver becomes unstable and oscillations swamp the signal you are trying to receive.

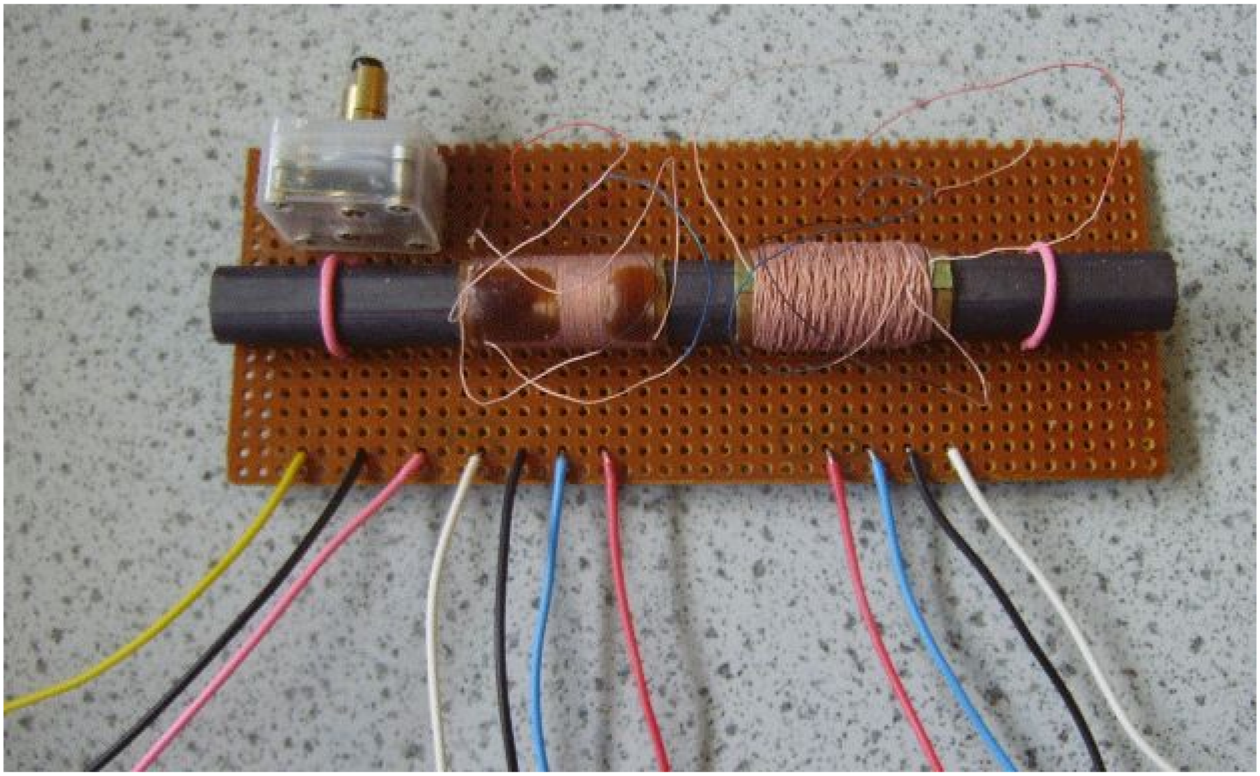


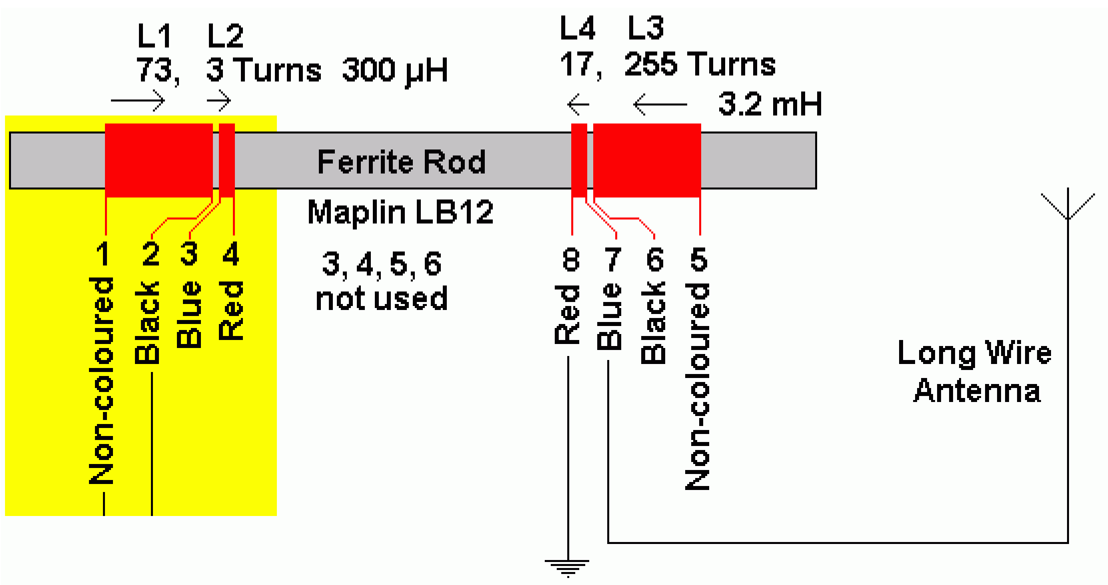
MK484 and ZN414 Pin Compatibility

We have replaced a ZN414 with an MK484 on one of our AlphaKit radio modules. It seems to work at least as well as the original. The pinout is different and the MK484 has to be soldered in, apparently the wrong way round. No other components were altered.



Ferrite Rod





L1
73,
L2
3 Turns 300 µH
L4
17,
L3
255 Turns
3.2 mH
Ferrite Rod
Maplin LB12
3, 4, 5, 6
not used
1
Non-coloured
2
Black
3
Blue
4
Red
8
Red
7
Blue
6
Black
5
Non-coloured
Long Wire
Antenna

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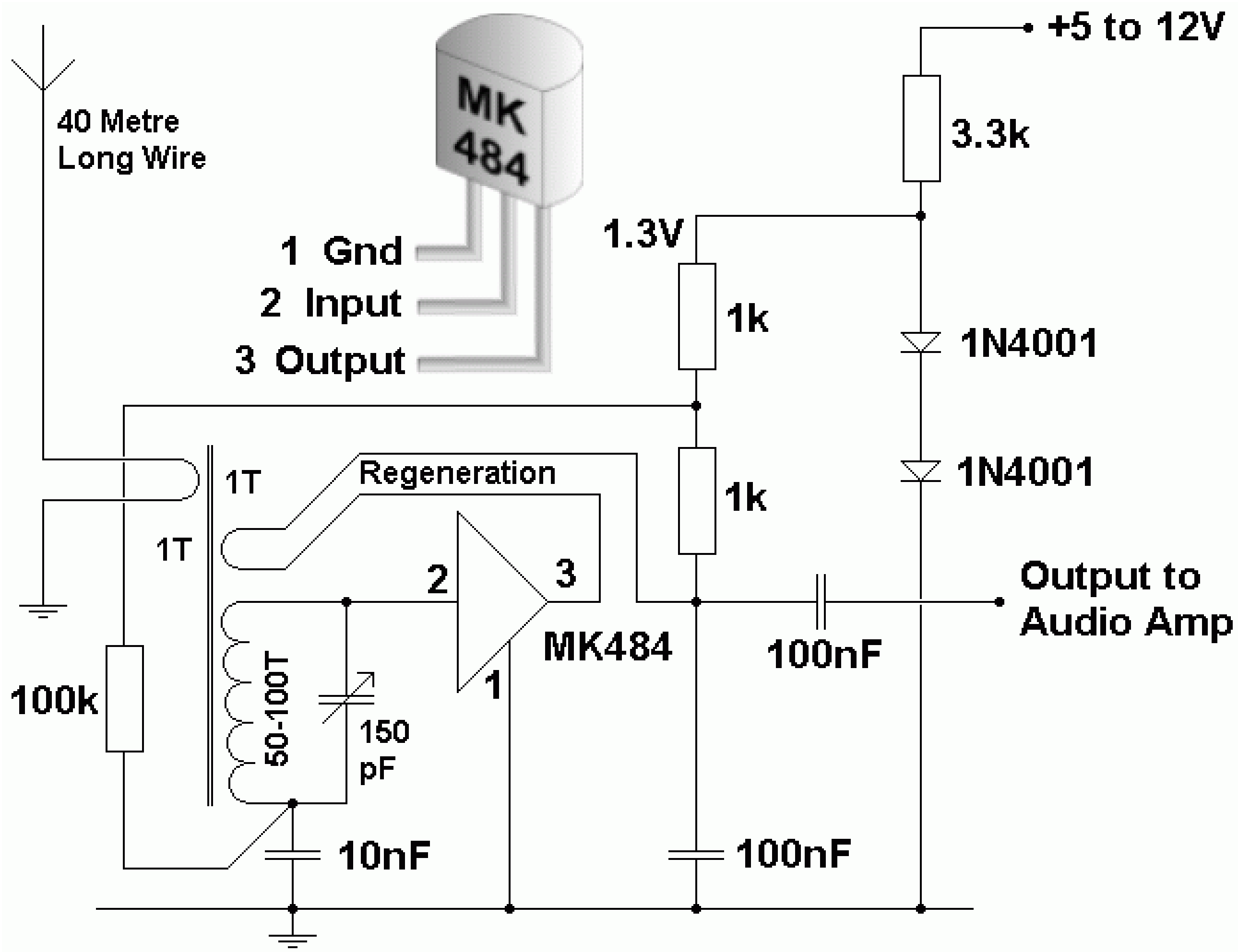

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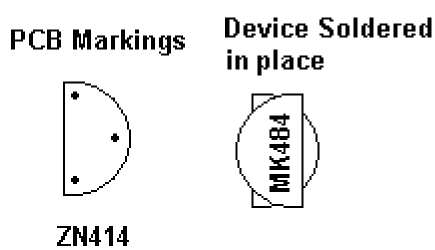
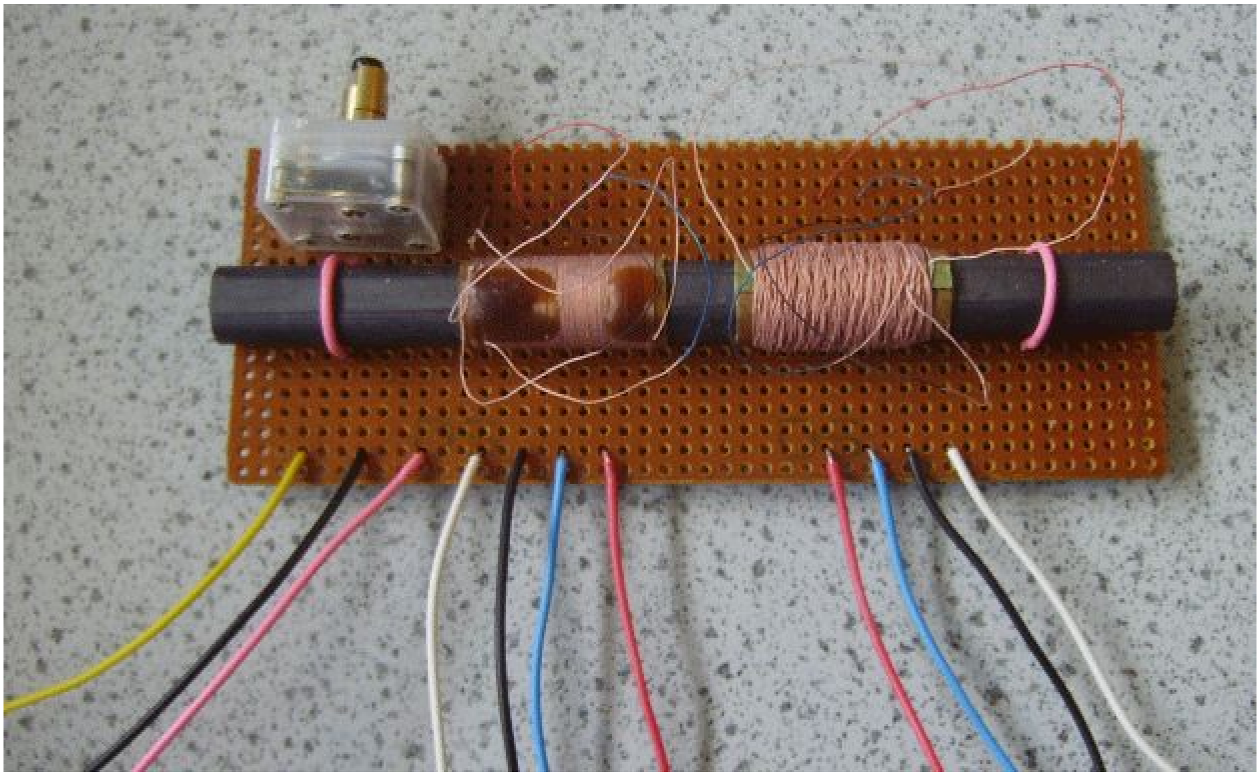
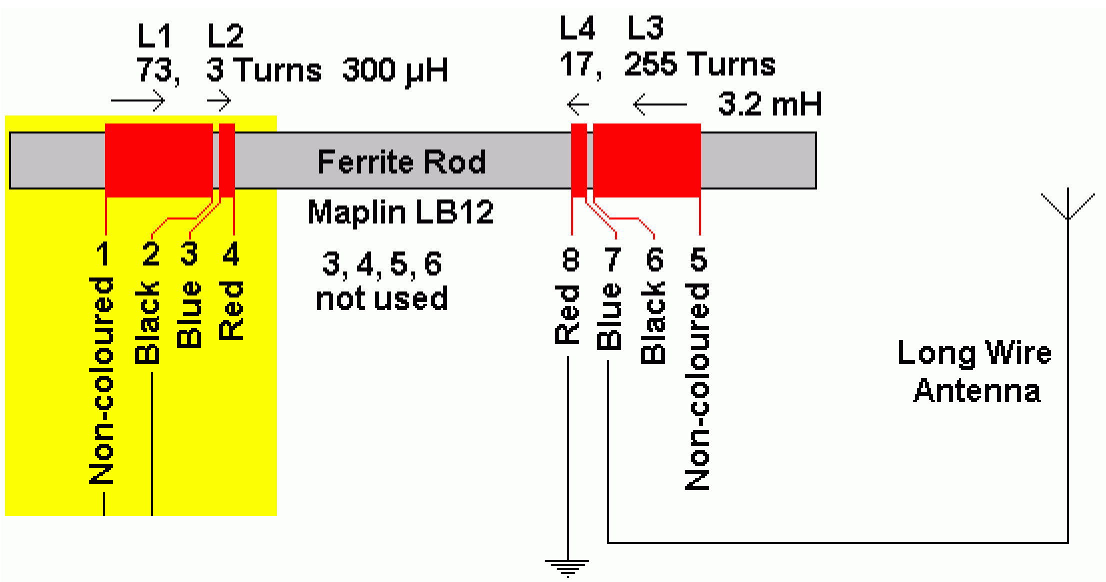


Ferrite Rod





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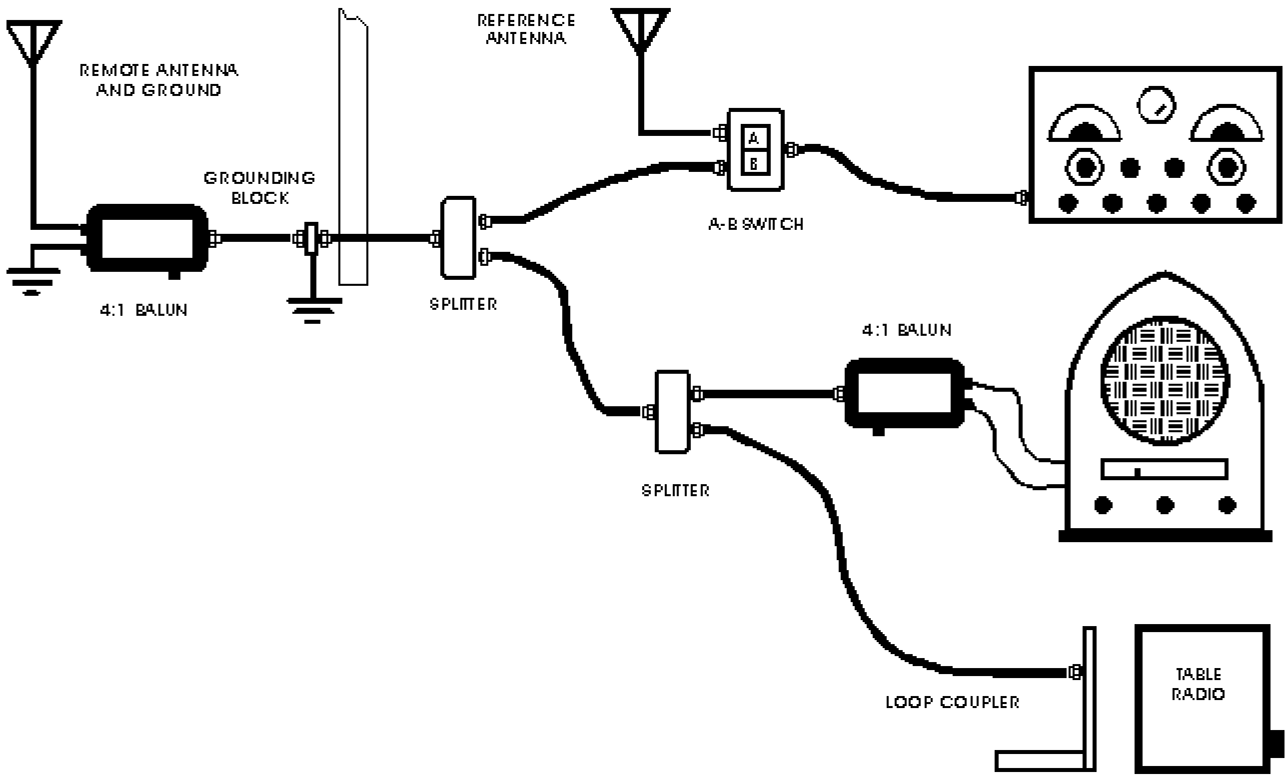
SWL Antenna Distribution System

I have developed a methodology for connecting multiple LF/MF/HF receivers to a single antenna via readily available and inexpensive 75-ohm TV cable. Custom made baluns and splitters provide impedance matching and prevent interaction between receivers. The following drawing shows a representative system. Construction details are given below.



UPDATED INFO	• Broad-namd transformers based on binocular coils: BALUNS • Simple, effective active antenna: ACTIVE • Order cores from ByteMark BN-43-202 is now known as B-202-43

4:1 Balun

- Provides matching from random wire antenna to coax.
- Also allows separation of antenna ground from building ground to prevent noise pickup.

Grounding Block

- Installed at entry point to building to head off lightning.
- Standard CATV device
- Electrical code calls for connection to an 8-foot ground rod.

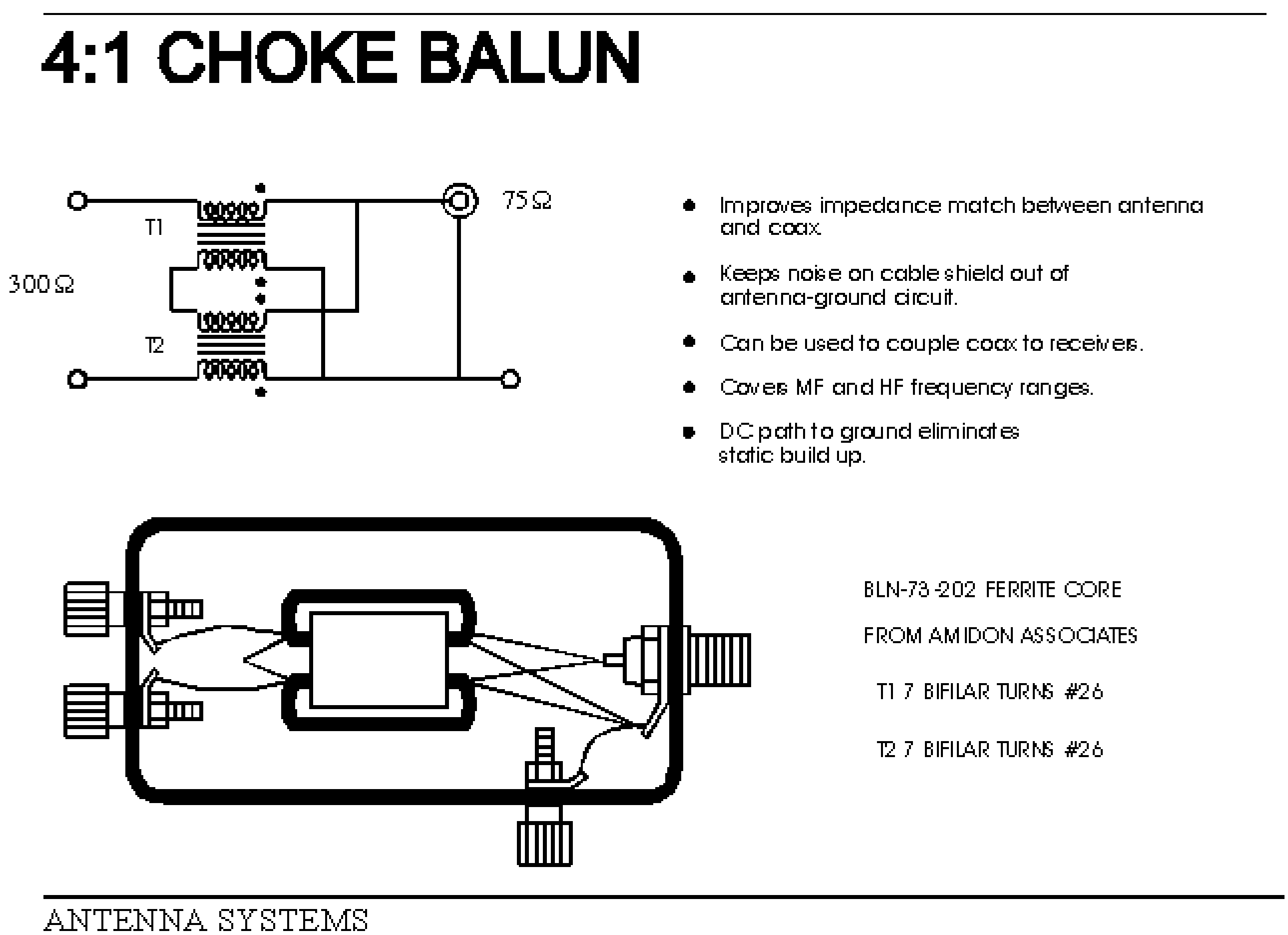
- ## 3-dB Hybrid Splitter

- Divides signal between two outputs and maintains 75-ohm impedance.
- Provides 30dB isolation between outputs.
- Broadband: 30KHz to 30MHz.
- CATV splitters don't work well below 10MHz.

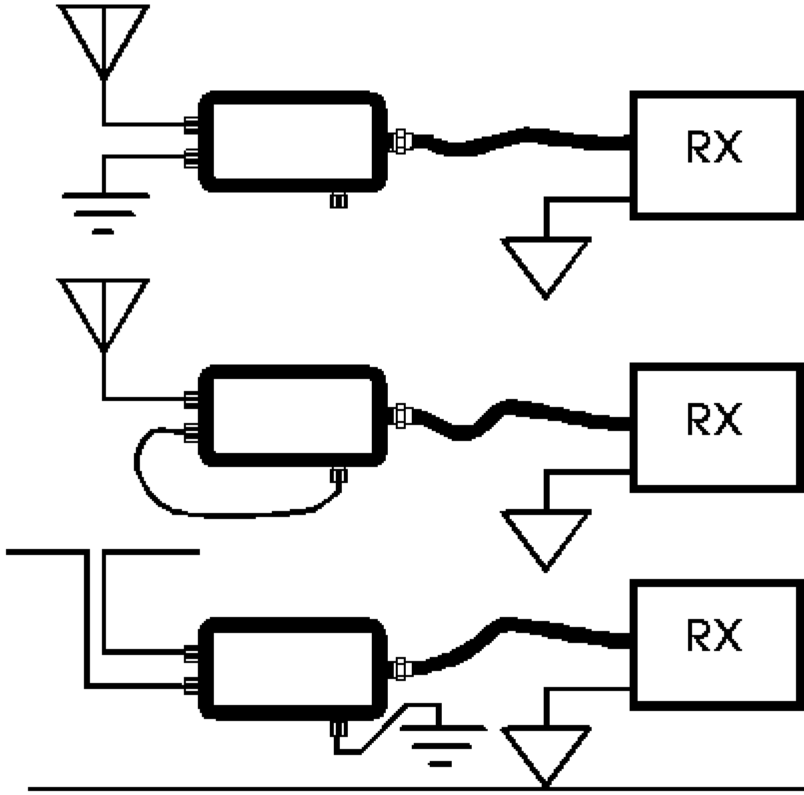
- **A/B Switch**
  - In this case, allows comparison of the new antenna to the old "reference" antenna.
  - Standard CATV device.

- **4:1 Balun**
  - Matches 75-ohm cable to old fashioned A-A-G inputs which are usually 300-400 ohms.
  - Same component as above.

- **Loop Coupler**
  - Couples 75-ohm coax to receivers with internal loop antennas, e.g. table radios.

- 

BALUN APPLICATIONS



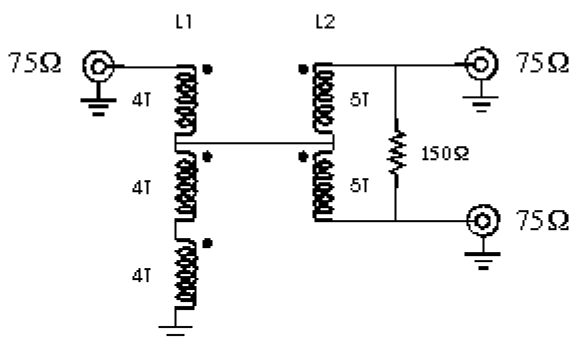
Antenna operated against earth cable isolated.

Antenna operated against cable shield.

BALANCED (DOUBLET) ANTENNA.

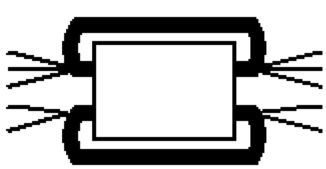
- ANTENNA SYSTEMS

3dB SPLITTER/COMBINER



- Divides input power in half while maintaining 75 ohm impedances.
- Wide bandwidth: <100KHz to >30MHz
- Hybrid design provides >30dB isolation between outputs.
- Can also be used to combine two signals with no loss.

L1 4 TRIFILAR TURNS #26



BLN-73-202 FERRITE CORE

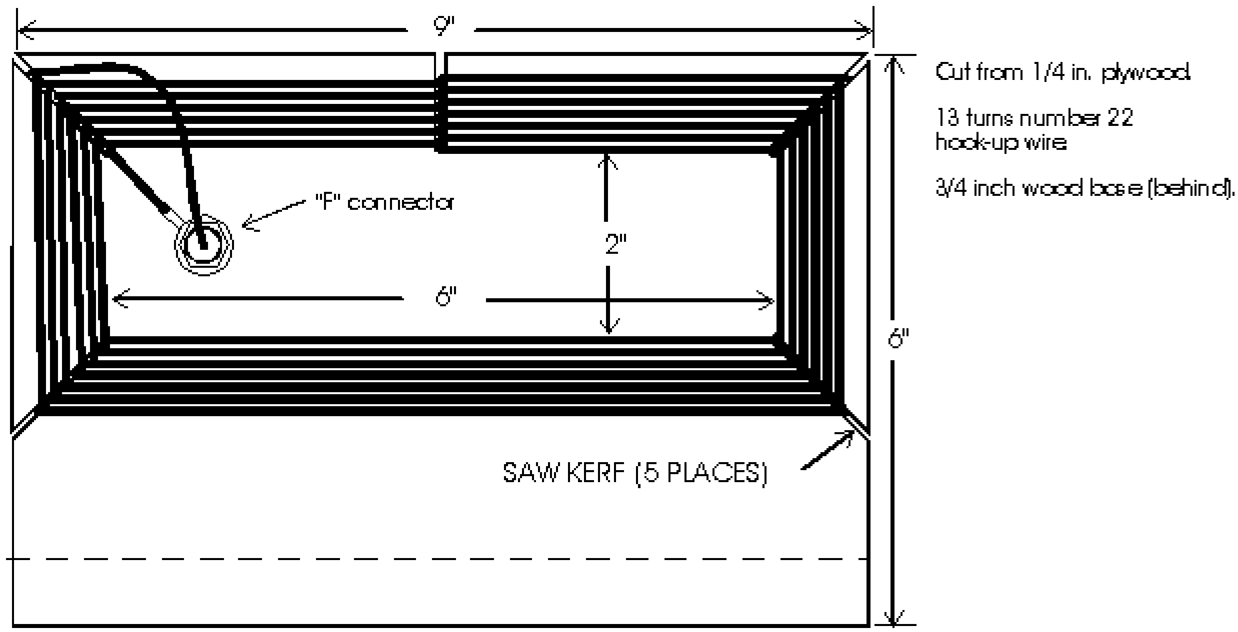
FROM AMIDON ASSOCIATES

L2 5 BIFILAR TURNS #26

ANTENNA SYSTEMS

LOOP ANTENNA COUPLER

Connects 75 ohm coax to receivers with loop antennas.



ANTENNA SYSTEMS

- **HOME**

5.8 GHz Directional PCB Antenna

Ali Bibonge

Jeff Dube

Curtis Evans

Anh Le

Specifications

A directional PCB antenna was required to operate in the 5.725 - 5.850 GHz ISM band with linearly polarized waves. The antenna had to interface with a 50 Ω SMA connectorization and be fabricated entirely from circuit traces, metal components, and solder. No discrete electrical components could be used. Additionally, the entire device had to fit within a 10 cm x 10 cm x 1 cm rectangular prism.

Design

A microstrip patch antenna was chosen because it is both an effective means of directing radiation and a simple device to fabricate on a PCB. A patch antenna is essentially a thin flat rectanglular conductor separated from a ground plane by a dielectric layer (Fig. 1).

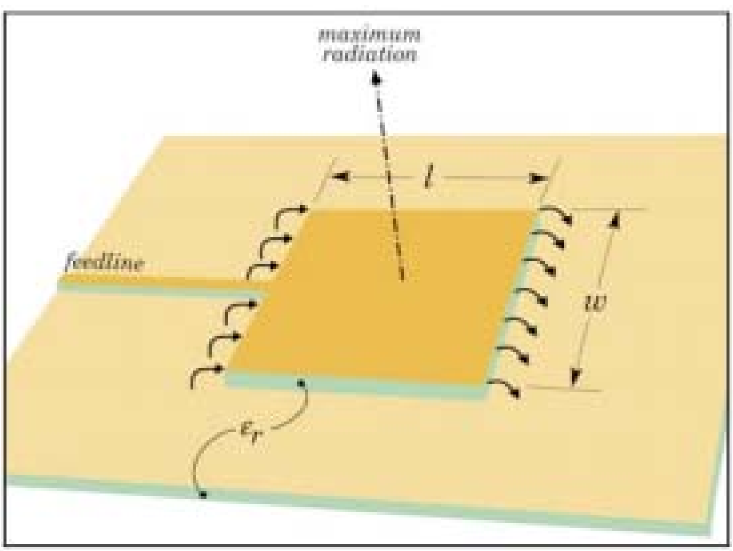


Figure 1. Typical patch antenna layout.

The edges of the rectangular patch are what provide the actual radiation. Coupled with the ground plane beneath, they act similarly to slot antennas. The currents in the patch "spill over" the edges, resulting in the desired radiation. Maximum gain occurs in a direction perpendicular to the plane occupied by the antenna, and polarization is parallel to the longest edges of the patch. The ground plane shields radiation on its side of the dielectric, reducing rearward gain. Larger ground planes provide more shielding, so to maximize gain in the forward direction, a ground plane much larger than the patch is preferred. The other factor for large ground plane is for the fringing field.

The patch was fed from the rear (through the bottom layer of the PCB) as opposed to the side. This eliminated any possible interaction that may have occurred between the antenna's edges and the feed system. The dimensions of an ideal rectangular patch were calculated using the equations shown in Figure 2.

$$Z_0 = \frac{120\pi h}{W\sqrt{\varepsilon_{\text{eff}}}}$$

$$\varepsilon_{\text{eff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-1/2}$$

$$\Delta l = 0.412h\left(\frac{\varepsilon_{\text{eff}} + 0.3}{\varepsilon_{\text{eff}} - 0.258}\right)\frac{(W/h) + 0.264}{(W/h) + 0.8}$$

$$f_r = \frac{c}{2\sqrt{\varepsilon_{\text{eff}}}(L + 2\ \Delta l)}$$

Figure 2. The equations used to calculate the patch antenna dimensions.

The antenna was then created by simply cutting a piece of copper tape to the calculated dimensions, and attaching it to a 10 cm x 10 cm PCB with a rear-fed connection. In testing, slight adjustments were made to the dimensions to tune the antenna to 5.8 GHz. The final dimensions of the patch were 1.476 in. x 0.820 in. Figures 3 and 4 show images of the final antenna.

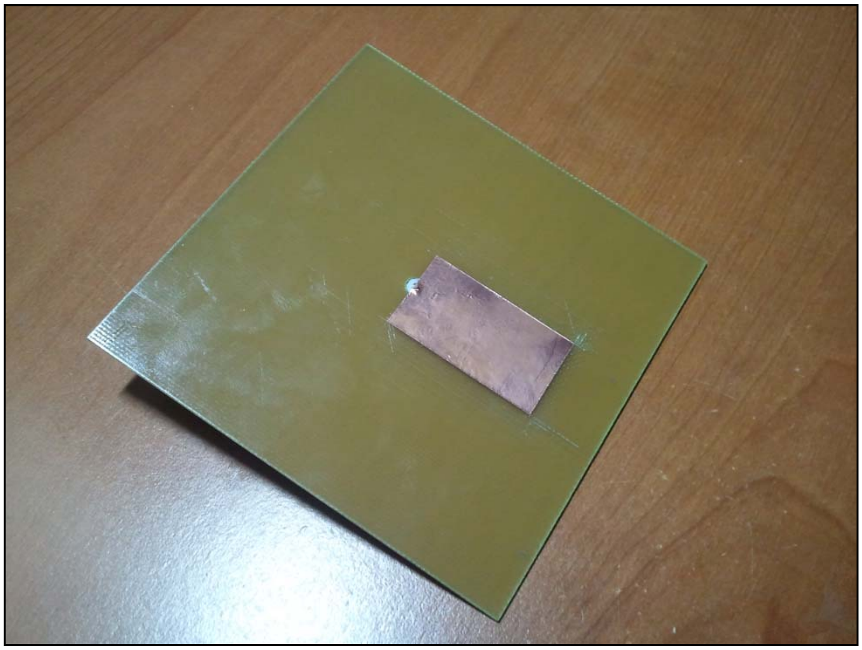


Figure 3. Patch antenna front.

Figure 4. Patch antenna back.

Testing

The return loss of the patch antenna was tested using a network analyzer. Measurements were taken over a frequency range of 1 GHz to 11 GHz. At 5.8 GHz, the return loss was measured at -26.97 dB (Fig. 5). The bandwidth was measured at approximately 500 MHz.

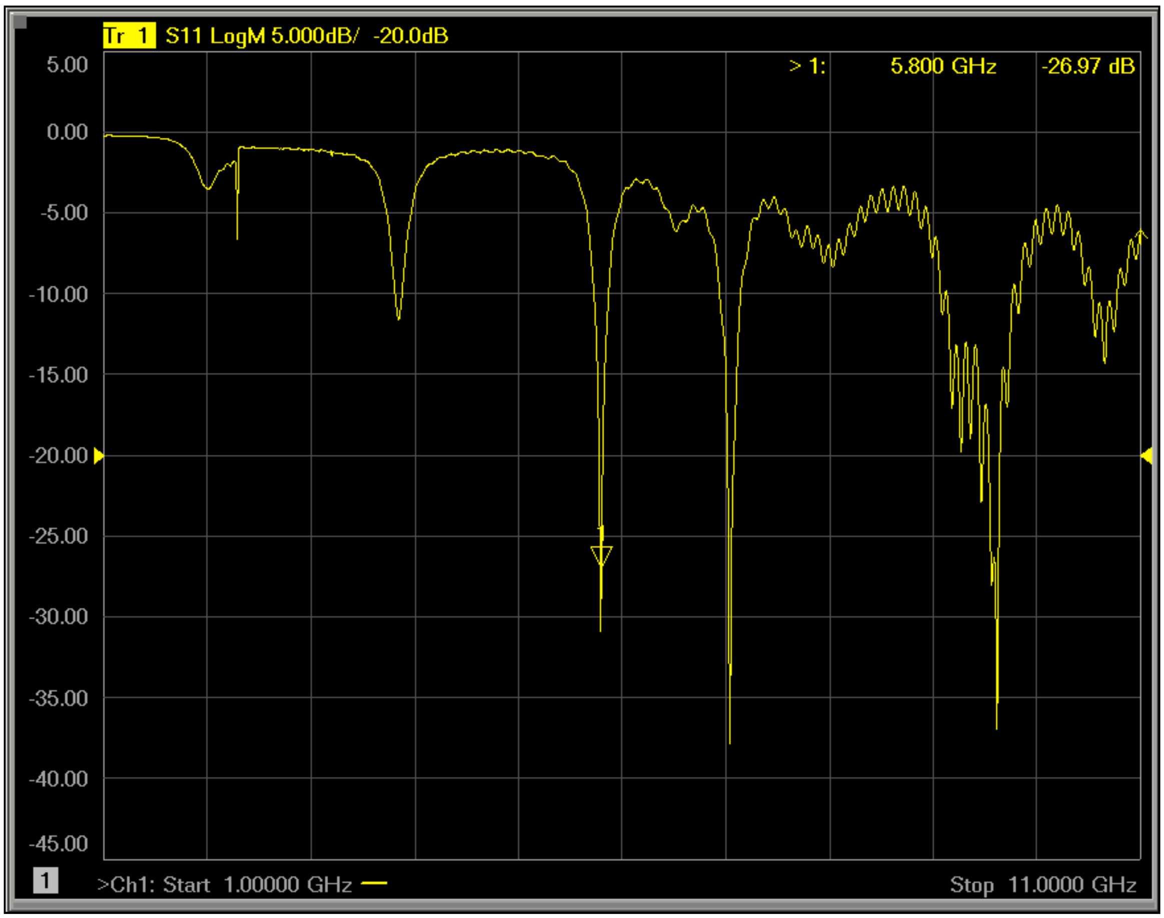


Figure 5. Return loss of the patch antenna, measured with a network analyzer.

References

1) Balanis, Constantine A. *Antenna Theory: Analysis and Design*, ed. 3. Hoboken, New Jersey: John Wiley & Sons, Inc., 2005.

2) Breed, Gary. "The Fundamentals of Patch Antenna Design and Performance". *High Frequency Electronics,* pp 48 – 51. Summit Technical Media, LCC, March 2009. http://www.highfrequencyelectronics.com/Archives/Mar09/HFE0309_Tutorial.pdf

3) Miranda, H. "Patch Antenna Design". Stanford, EE144/245, Spring 2007. https://ccnet.stanford.edu/cgi-bin/course.cgi?cc=ee144&action=handout_download&handout_id=ID11797377905639

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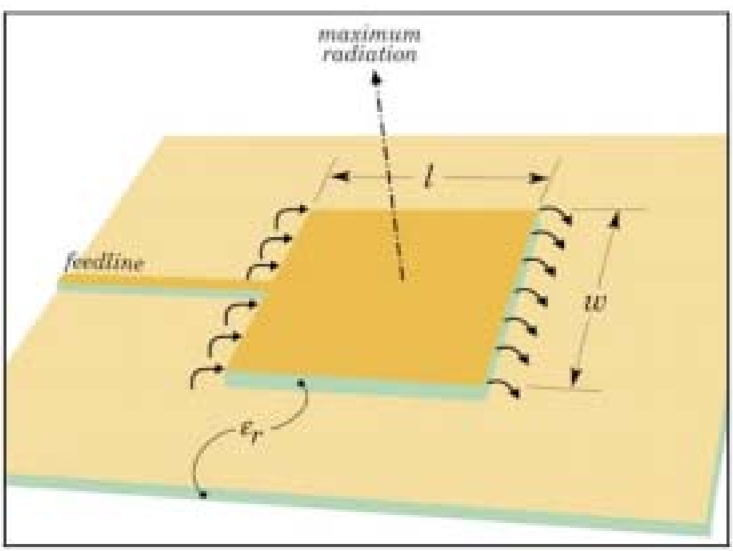

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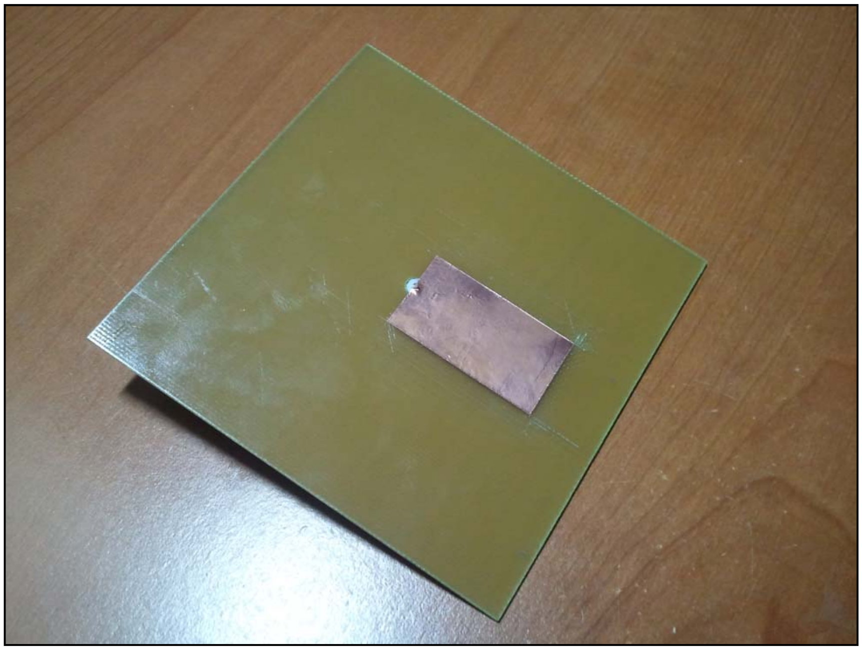

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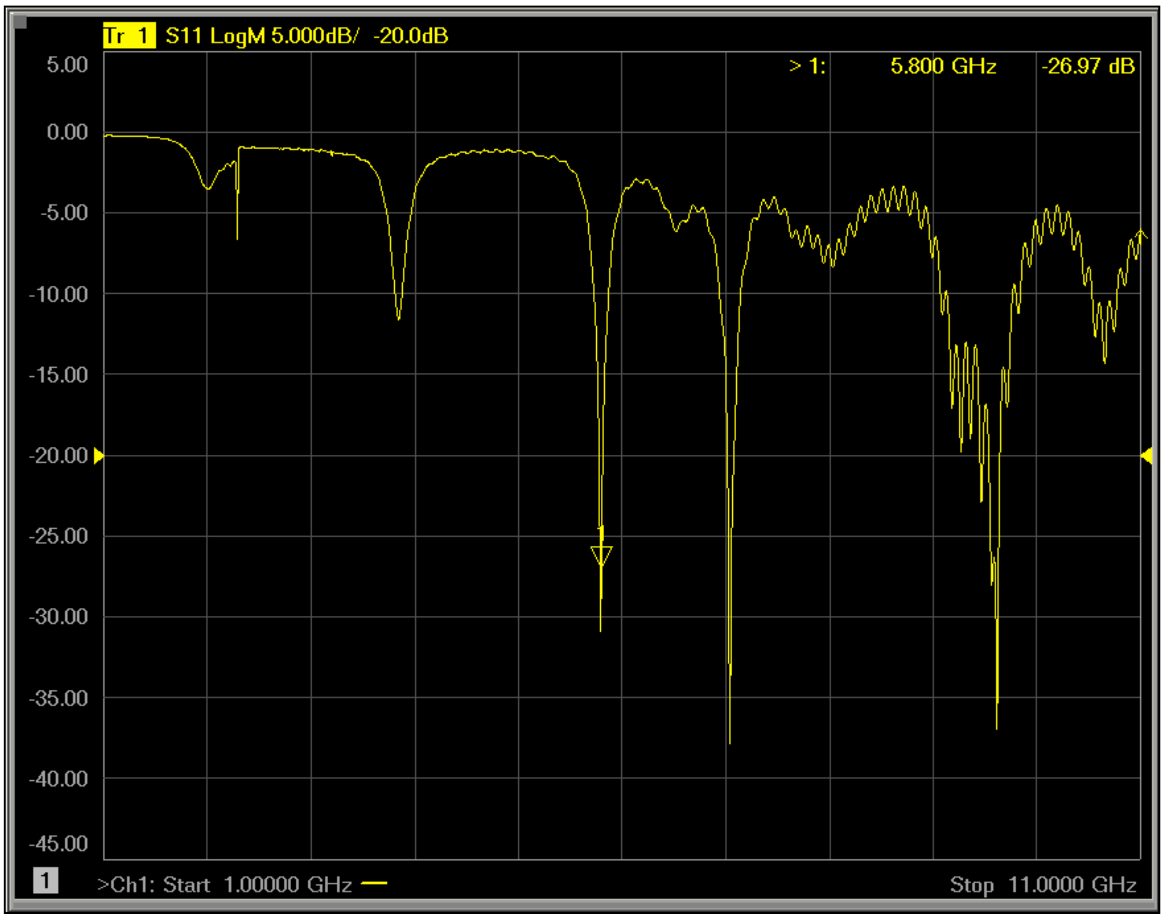

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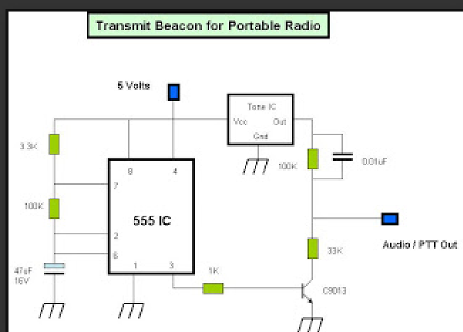
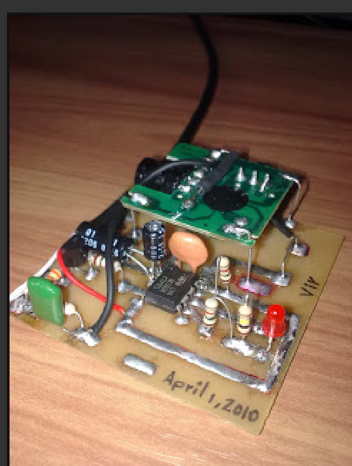
du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Friday, April 2, 2010

Transmit Beacon for Hand-held Radio





The circuit is run by 555 timer IC for its PTT sequence that is 4 seconds "on" and 4 seconds "off". Transmission is about 50% duty cycle that minimize the transmitter heat. Tone IC is any thing that generates sound, I got mine from a magnetic door open sensor which I bought from Japanese Store in Festival Mall. The prototype when connected to a portable transceiver is ready to go on air. ---73 de hevir

Posted by hevirred at 1:19 AM

3 comments:

Mike Bravo 7395 April 8, 2010 at 12:04 AM

wow ! bai hevir nindot ni project, keep up your work ! cge gyud ko visit sa u site kay daghan ka interesting projects ! hope to catch u on air ! mabuhay ka idol !
mike bravo/decada7

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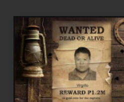

hevirred

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golden eagle April 23, 2014 at 10:37 AM

simply wonderful. thanks 73 de vu3inj. indrajit

hevirred April 25, 2014 at 5:09 AM

Thanks for visiting sir. 73 de du1vss.

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Scout Regen Receiver

Features

- The Scout Regen receives CW, SSB and AM signals from 3.5 to over 10 MHz. in two bands .
- Includes a painted and silk screened chassis, circuit board and all parts.
- Headphone level audio output with diode audio limiters to protect the listener.
- Powered by on board 9V battery or external supply.
- Current consumption of approximately 8mA.
- Sensitivity of up to -130 dBm or 0.1 uV.

Supporting Files and Documents

Scout Regen Builders manual (rev 1.2.1 5/4/09)

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Pacific Antenna Return Policy

GATE DIP METER

BY PRAVEEN C. GUPTA, VU2PPP

(There is great demand from new Hams for a suitable Gate dip Oscillator. Here is a circuit which appeared in 1977 in the then mouth piece of ARSI. You may use 2JPVC variable capacitors single section in place of Airdielectric Capacitor zone. The Gate resistor may be changed to 100 kilo ohms. BFW 10 or 11 can also be used.)

Here is yet another circuit of GDO but with a difference! Different, because it does not give false dips and meter needle stays at a constant level while checking for a dip. And, when the resonant frequency point is reached, it gives a very significant dip, which one just cannot miss! It is simple to make and sure to work, - the first time it is switched on ! Frequency coverage of this GDO can be extended to VHF region but has not been tried due to non-availability of VHF receiver.

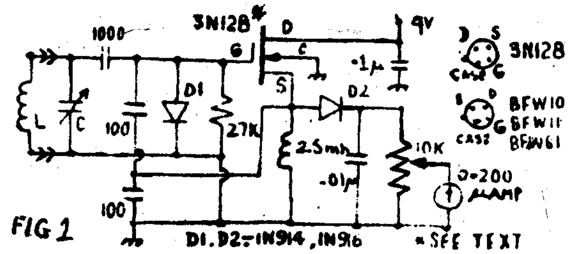


FIG 1

The circuit diagram of the dip meter is as shown in Fig. 1. It utilizes MOSFET 3NI28 in RF oscillator configuration (al though FET BFW 10, 11, 61 were tried with comparable success instead of 3NI28). The output of the oscillator is rectified by D2 and .01 mfd capacitor and is fed to 0-200 microampere meter through 10K linear potentiometer to adjust for a convenient level of current in the meter.

The Dip Meter is constructed in an aluminium box, abundantly available in utensil shops as tiffin box (rectangular shape) Mechanical lay-out is slightly critical. Before attempting to solder the components, it is better to complete the mechanical lay-out first. Refer to Fig. 2, Notice that the plugin coils are made out of audio phono jacks (do not hesitate - they work well upto HF range end!). Fix female phone jacks, variable capacitor, tuning meter, potentiometer and on-off switch at the positions shown in Fig 2. Complete the inter-connection wirings of these components using shortest possible wires. Then wire the remaining circuit on a small general purpose pc board using point to-point wiring. Cover the complete board with insulation tape, with only the interconnecting wires coming out. Complete the inter-connection of pc board with other components. Lastly solder the battery connections and place it just below the variable capacitor with the help of two sponge pieces to make it tight fit. Recheck the wiring, making sure that there is no short in inter-connecting wiring. Close the back cover. Next, prepare the coils as per Fig. 3. Make sure that the 'hot end' of the coil always forms the top layer and is near the top-end of the plug-in coil.

Plug in one of the coils and switch on Dipper (Do NOT switch on, when coil is not plugged-in. It is because the circuit draws more current when not oscillating). Adjust the potentiometer till the needle is in the centre of the scale of the meter. If the needle of the meter moves by changing potentiometer it shows that the oscilator is working and that the job is almost complete. If it does'nt, re-check wiring. Now squeeze the plug-in coil between two fingers, the oscillator will stop oscillating, and the meter needle will dip. Check all coils in similar way.

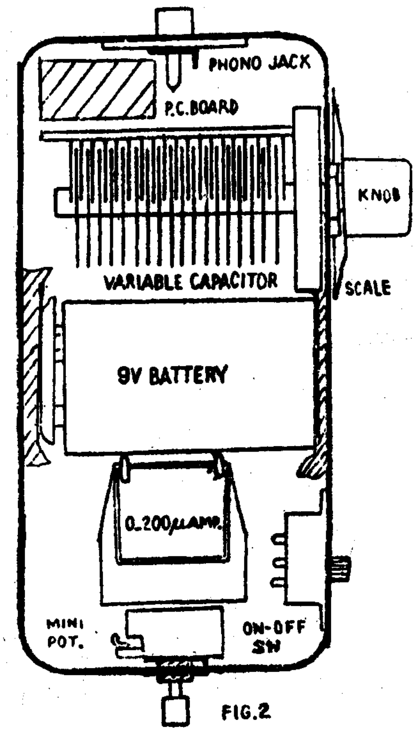


FIG.2

Although coil data is given, yet the dipper will require calibration by a well calibrated receiver, as it is feared that

The plug-in Coil. See data below.

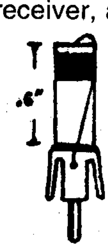


FIG.3

the variable capacitors may not be having the same stretch of capacity in each case. Keep the variable capacitor fully meshed-in. Align zero of circular scale with marking on the knob. Plug-in coil L1 and switch on calibrated receiver, keeping the dipper near the receiver antenna. Tune the receiver somewhere near 4MHz and slowly start tuning up

in frequency till a strong whistle is heard in receiver due to dipper oscillator. Make sure that the whistle is due to dipper oscillation, by switching on-off the dipper or by touching the coil of dipper with finger Note the frequency.Keep increasing the receiver frequency in steps of 1/2 MHz and every time adjust dipper to get a whistle in the receiver, noting down the corresponding readings in the scales. Tabulate the result, which can be pasted on the front panel for easy reference. This completes the calibration of GDO.

COIL DATA

All coils close-wound on 1/4 dia forma except 4.4 to 7.5 MHz (L1), which is in 1/2 dia former.

1. 4.4 to 7.5 MHz 27t 32 swg.
2. 7.5 to 12.7 MHz 20t 32 swg.
3. 12.5 to 20 MHz 11t 26 swg.
4. 19.7 to 32 MHz 5t 25 swg.

HOME BREW

NSH26VA

THINGS TO LEARN, PROJECTS TO BUILD, AND GEAR TO USE

by N.S. Harishankar VU3NSH.

SPECIFICATIONS & FEATURES

- 13V DC output	- 86dB Ripple rejection
- 1.8 A Auto limit	- DC high voltage protection
- 'BUS' indication	- 130V- 240V AC input
- 'Vin low' indication	- 100% RF immune

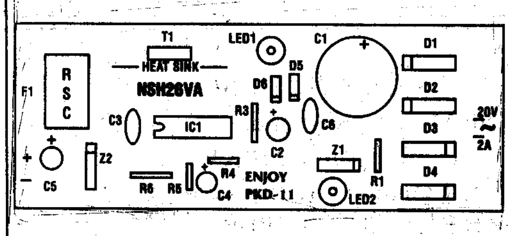
It is an economical power supply with standard protections meant for QRP or 2M/70cm TXVER users. The heart of this design is based on LM723IC. IC LM723 is very very popular since Y74 till now, 25 Yrs old!!; It is so because the IC is easily configured to different voltage levels and different current limits automatically with lot of features like low temperature drift, high ripple rejection, low stand by current etc.

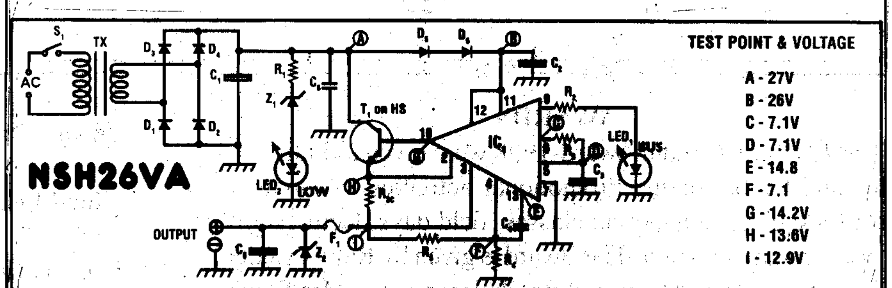
In this circuit, IC is configured to get 13V output and 1.8A I Limit MAX. Additional features are added like 'BUS' indicator, low Vin indicator and simple high voltage DC output protection etc. All 2m (VHF) TXVER's max working voltage is 15 V-16V; and the ideal voltage is 13.8V. The MAX DC current consumption for 5 WRF output is 1.4A i.e., for 5WRF output, DC power conception in 13.8V x 1.4A= 19W. This circuit gives 13V and MAX current upto 1.8A. Many HAMS are using general eleminator or regulated power supply without high voltage DC output protection; They are producing 50HZ QRM while transmitting and some regulated PSU without high voltage DC output protection. Sometimes these regulated PSUs give very high DC voltage output (Equal to Vin) and TXVER becomes QRT. What's wrong? If you are using external regulate dPSU, due to high temperature, appropriate components, low AC input span, strong RF field etc. will make high DC output voltage or 50HZ QRM. In this design Z2 is used for high voltage protection. When the output DC voltage is more than 15V or above F2, it will blow off. The current limit is set by resistor Rsc. I limit is calculated by this formula ILmt=0.6/Rsc. The 'BUS' indicator LED1 (green) will glow normally. It is monitoring the proper output from the IC if 'bus' LD1 goes off. i.e., output voltage from IC is below 6V or nil. So the glow of LED1 is good sign of the proper condition of IC. LED2 is normal Vin indicator. If the Vin voltage is 15V or low. Then LED2 (red) turns off. In this condition, while TXVER on TX mode will give 50HZ QRM. Use 0-20V 2A (20V-40V A) transformer. Never change the specified component values. Use large heatsink for TIP 33; large heatsink allows heavy duty cycle. D5, D6 and C2 provides a separation (decoupling) from Vin to IC supply.

Capacitor C3 gives high ripple rejection upto 86 dB; using 20V/2A-240V input transformer, the AC voltage span is increased like 130V to 240V. PCB with Component Layout is available with the author.

SEMI CONDUCTORS	RESISTORS
IC-LM723	Rsc-0.33 2W 5%
T1-TIP33	R1- 1K5 1/4W 5%
D1 to D4- 1N5408	R2- 1K2 1/4W 5%
D5, D6- 1N4007	R3- 3K3 1% MFR
Z1 - 15V-400mW	R4- 5K6 1% MFR
Z2 - 1N5352B	R5- 4K7 1% MFR
LED1 - Green 5mm	
LED2 - Red 5mm	

CAPACITORS	MISCELLANEOUS
C1 - 3300uF50V	TX 0 - 20V 2A - 240VPri
C2 - 100uF50V	Heatsink - SK104
C3 - 10uF35V	50mm
C4 - 1Kp	F1 - 2A QB
C5 - 100uF40V	PCB, Cabinet,
C6 - 0.1uF100V	





By Charles Kitchin, N1TEV

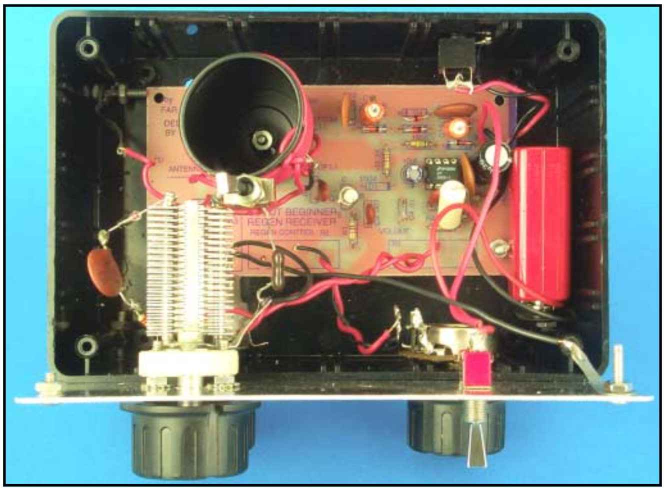
A Simple Regen Radio for Beginners

Need a simple, fun project—possibly for a Scout Radio Merit Badge? This project is a great way to introduce kids of any age to electronics and shortwave listening.

Here's a low cost, simple-to-build, portable shortwave receiver. Its design is noncritical and the receiver is easy to get going. With it, you can receive dozens of international shortwave broadcast stations at night—even indoors—using a 39-inch whip antenna. This little radio is perfect for discovering ham-band QSOs, news, music and all the other things the shortwave bands have to offer.

Although this little receiver is quite sensitive, it naturally won't match the performance of a commercial HF rig, and if you've not used a regen before, you'll have to practice tuning the radio—but that's part of the adventure. Most of today's experienced "homebrewers" got their start by building simple, fun circuits just like this one. You'll gain experience in winding a coil and following a schematic. As your interest in radio communication develops, you can build a more complex receiver later.

The little receiver requires only a single hand-wound coil and consumes just 5 mA from a 9-V battery. At that rate, an alkaline battery can provide approximately 40 hours of operation. The sound quality of this receiver is excellent when using Walkman headphones. The radio can also drive a small speaker. To simplify construction, a low-cost PC board is available from FAR circuits.[1] You can house the receiver in a readily available RadioShack plastic project box.



In this version of the receiver, a prototype PC board is used; it is not directly representative of the currently produced board, although they are similar. In this view of the receiver, the antenna has been removed. The TUNING capacitor is at the left. Immediately behind the capacitor is the coil, L1. Attached between the TUNING capacitor and the VOLUME control pot immediately beneath you can see D1, C4 and R4 as discussed in the text.

Circuit Description

Take a look at the schematic in Figure 1. L1 and C1 tune the input signal from the whip antenna. Regenerative RF amplifier Q1 operates as a grounded-base Hartley oscillator. Its positive feedback provides a signal amplification of around 100,000. The combination of the very low operating power of this stage, only 30 µW, with the use of a simple whip antenna makes this receiver easily portable and prevents it from interfering with other receivers located nearby. Regenerative receivers are, after all, oscillators. R2 controls the amount of positive feedback (regeneration).

D1 and C4 comprise a floating detector that provides high sensitivity with little loading of Q1. The relatively low back-resistance of the 1N34 germanium diode (don't use a silicon diode here!) provides the necessary dc return path for the detector.

[1]Notes appear on page 64.

VOLUME control R5 sets the level of detected audio driving U1, an LM386 audio amplifier. C5 provides low-pass filtering that keeps RF out of the audio amplifier. R4 isolates the low-pass filter from the detector circuit when the volume control is at the top of its range. The bottom of the **VOLUME** control, R5, and pin 3 of the LM386 float above ground so that both inputs of the IC are ac coupled. This allows the use of a 100-kΩ **VOLUME** control; this high resistance value prevents excessive loading of the detector. D5 protects the receiver from an incorrectly connected battery.

L1 is wound on a standard 35-mm plastic film can or a 1-inch-diameter pill bottle. C1 can be any air-dielectric variable capacitor with a maximum capacitance of 100 to 365 pF. Total frequency coverage varies with the capacitance value used, but any capacitor in that range should cover the 40-meter ham band and several international broadcast bands. If you use a capacitor with a large capacitance range (such as 10 to 365 pF), you'll find that selectiv-

ity suffers. That is, it's more difficult to tune in an individual station because there are more stations within the tuning range than when using a capacitor with a smaller capacitance range (such as 10 to 150 pF). Therefore, an optional fine-tuning control (see the inset of Figure 1) is recommended when using tuning capacitors with a wide capacitance range.

Building the Receiver

Finding the Parts

Air-dielectric variable capacitors can be purchased from several suppliers.[2] You can also find them at ham flea markets or salvage one from a discarded AM radio. All the other components are available from RadioShack and Digi-Key. PC boards are available from FAR Circuits (see Note 1).

Winding the Coil

Some would-be builders are intimidated by the idea of winding a coil. Actually it's quite easy to do. Sometimes, having a second set of hands helps. For the coil winding, use 22-gauge solid-conductor insulated hook-up wire. Before you start winding the coil,

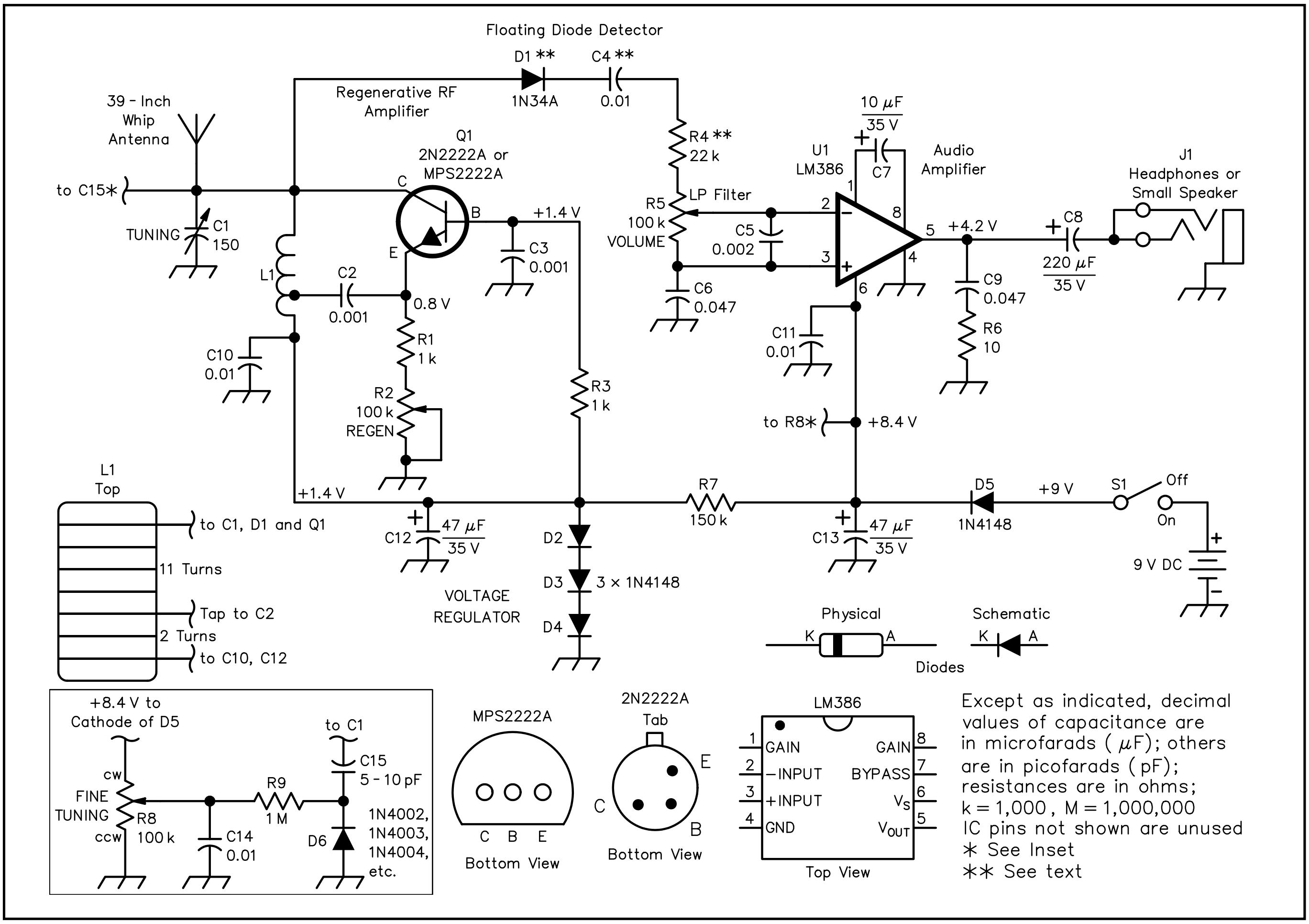
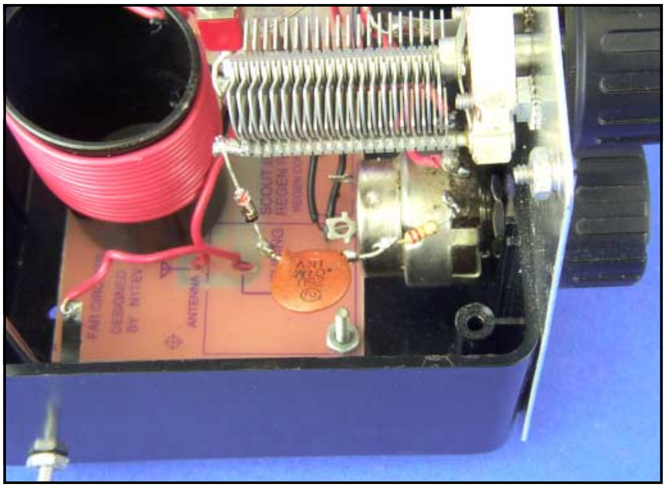


Figure 1—Schematic of the simple regen receiver. Unless otherwise specified, resistors are 1/4-W, 5%-tolerance carbon-composition or metal-film units. Part numbers in parentheses are RadioShack. Equivalent parts can be substituted; n.c. indicates no connection.

C1—150 to 350 pF (maximum value) air-dielectric variable capacitor; see text.
C2, C3—0.001 µF, 50 V (or more) disc ceramic (RS 272-126)
C4, C10, C11, C14—0.01 µF, 50 V (or more) disc ceramic (RS 272-131)
C5—0.002 µF, 50 V (or more) disc ceramic (use two RS 272-126 connected in parallel).
C6, C9—0.047 µF, 50 V disc ceramic (RS 272-134)
C7—10 µF, 35 V electrolytic (RS 272-1025)
C8—220 µF, 35 V electrolytic (RS 272-1017)
C12, C13—47 µF, 35 V electrolytic (RS 272-1027)
C15—5 to 10 pF, 50 V (or more) mica (RS 272-120)
D1—1N34A *germanium* diode (RS 276-1123); don't use a silicon diode here.
D2-D5—1N4148 or any similar silicon diode (RS 276-1122)
D6—1N4003 silicon diode (RS 276-1102)
J1—2 1/8-inch, three-circuit jack (RS 274-246)
L1—See text.
Q1—2N2222A NPN transistor (RSU11328507) or MPS2222A (RS 276-2009)
R1, R3—1 kΩ (RS 271-1321)
R2, R5—100 kΩ potentiometer, linear taper (RS 272-092)
R4—22 kΩ (RS 271-1339)
R6—10 Ω (RS 271-1301)
R7—150 kΩ (RSU11345287) or use series-connected 100 kΩ (RS 271-1347) and 47 kΩ (RS 271-1342) resistors.
R8—100 kΩ audio-taper pot (RS 271-1722); connect so that clockwise rotation increases the voltage at the junction of the pot arm, R9 and C14.
R9—1 MΩ (RS 271-1356)
S1—SPST miniature toggle (RS 275-612)
U1—LM386N-1 audio amplifier (RS 276-1731)
Misc: PC board (see Note 1); 39-inch whip antenna (RS 270-1403); 8-pin DIP socket for U1 (RS 276-1995A); 9-V battery clip (RS 270-325); three knobs (RS 274-402A); project box (RS 270-1806); #6-32 screws and nuts, rubber feet; 9-V battery, Radio Shack 22-gauge solid hook-up wire. Note: RSU items in the RadioShack catalog need to be ordered (delivery in approximately 7 to 10 business days).



This close-up shows the interconnection of series-connected D1, C4 and R4 between the TUNING capacitor and VOLUME control.

drill a mounting hole in the bottom of the film can or pill bottle. Then, drill two small holes in the side of the coil form, near the top, where the winding starts. (By winding from the top of the coil form to the bottom, the winding bottom is kept well above the PC board, preventing any circuit loading that could decrease the receiver's selectivity.) Feed one end of the coil wire through the first hole to the inside of the form, then out through the second. Tie a knot at the point in the wire where it enters the form—this keeps the wire in place and prevents it from loosening later on. Be sure to leave a two to three inch length of wire at each end of the coil so you can make connections to the PC board.

You can wind the coil in either direction, clockwise or counter-clockwise. Tightly wind the wire onto the form, counting the turns as you go. Keep the turns close together and don't let the wire loosen as you wind; this takes a little practice.

To make the coil tap, wind 11 turns on the coil form. While holding the wire with your thumb and index finger, mark the tap point and remove the insulation at that point. Solder a two to three-inch piece of wire to the tap. Continue winding turns until the coil is finished (13 turns total). Keep the free end of the wire in place using a piece of tape and drill two more holes in the coil form where the winding ends. Feed the wire end in and out of the coil as before and tie a knot at the end to hold the winding in place. When the coil is finished, remove the tape then carefully solder the three wires from the coil (bottom, tap and top) to their points on the PC board keeping the wire lengths as short as possible.

For best performance, the floating detector must be wired using short, direct connections. Therefore, these components are not mounted on the PC board. Mount the **VOLUME** control, R5, close to the **TUNING** capacitor, C1. Connect D1, C4 and R4 in series between the hot side of C1 (the stator) and the top of the **VOLUME** control.

Options

Fine-Tuning Control

You can add a fine-tuning control to the receiver using the circuit shown in the inset of Figure 1. D6 functions as a poor man's Varactor (voltage-variable capacitor). As the voltage from **FINE-TUNING** control R8 is increased, the diode is reverse biased and its capacitance decreases. This fine-tuning control is cheap and easy to add, but its added capacitance somewhat reduces the maximum frequency range of the receiver. You can compensate for this by removing turns from L1 if necessary.

Two-Band Option

If you'd like a two-band receiver with noncritical tuning, use a 150-pF capacitor for C1 and install a miniature toggle switch with very short leads to add an additional 250-pF fixed-value mica capacitor in parallel with C1. With the capacitor in the circuit, the receiver will then tune the 80-meter band.

Packaging the Radio

The recommended RadioShack project box includes metal and plastic tops. Use the metal top as a large front panel by mounting it to one side of the box using two small screws and nuts through two of the four predrilled holes. Then drill the control mounting holes and mount the three controls and the **ON/OFF** switch on the metal panel. The radio is easier to operate if you mount the **TUNING** capacitor and the regeneration (**REGEN**) control on opposite sides of the front panel. The **VOLUME** and **REGEN** controls are best mounted near the bottom of the front panel to keep their connecting wires to the PC board as short as possible. You can use the RadioShack hook-up wire for the **VOLUME** and **REGEN** control connections if you twist the wires closely together and keep their lengths very short. Otherwise, use shielded wires for these connections. You can mount the **ON/OFF** switch last, in any convenient location. Use one of the two remaining holes in the metal front panel to attach a wire connecting the panel to the PC board ground. Attach the PC board and the coil to the bottom of the project box using small screws. Mount the headphone jack on the box rear, close to the PC board and the LM386. Attach the RadioShack 39-inch whip antenna to one of the back corners of the box using a small screw and nut.

If you use the RadioShack jack specified for J1 (RS 274-276), connect together pins 2 and 5 and attach that common lead to C8. Ground pin 1 of the jack. If you intend to use a small speaker, connect it between pins 1 and 3. Then, when headphones are plugged in, the speaker will be disconnected automatically.

Testing and Operating the Receiver

Set the **VOLUME** and **REGEN** controls to midrange, plug in the headphones, extend the whip antenna, attach the battery and turn on the receiver. You can check to ensure that the audio stage is functioning by placing a finger on the center lug (wiper) of the **VOLUME** control and listen for a buzz. If the audio stage is working, adjust the **REGEN** control until the set produces a sound, indicating that Q1 is oscillating. If Q1 is not oscillating, carefully check the wiring and measure the voltages labeled on the schematic using a high-impedance DVM or multimeter. Common problems are Q1 being wired backwards (emitter and collector connections reversed) and the wires from coil L1 connected to the wrong places on the PC board.

Use two hands when operating the receiver: one for tuning, the other for controlling regeneration. For international broadcast stations or AM phone operation on 40 meters, carefully adjust the **REGEN** control so that Q1 is just below oscillation. For CW and SSB, increase the **REGEN** level so that the set *just* oscillates providing the required local oscillation for these modes. This receiver picks up lots of stations with just its whip antenna, although using a ground connection will greatly reduce any hand-capacitance effects. To pull in more stations during daylight hours, a 10 to 15-foot (or longer) length of insulated hook-up wire can be used as an external antenna. Simply wrap the end of this wire a couple of times around the whip antenna.

If you operate this receiver close to another radio, the regen's 30-µW oscillator might interfere with it. Those who are interested

in building a higher-performance regen receiver for serious CW and SSB reception should read my article "High Performance Regenerative Receiver Design."[3] You can also see the project at **http://www.electronics-tutorials.com/receivers/regen-radio-receiver.htm**

Notes

[1]A PC board for this radio is available from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269, tel 847-836-9148 (voice and fax). Price: $5 each plus $1.50 shipping for up to three boards. FAR Circuits offers a group discount rate of 10% for orders of 10 or more boards. Visa and MasterCard accepted with a $3 service charge; **farcir@ais.net**; **http://www.cl.ais.net/farcir/**.

[2]Suppliers include, but are not limited to: Antique Electronics Supply, 7221 S Maple Ave, Tempe, AZ 85283; tel 480-820-5411, fax 800-706-6789, 480-820-4643; **info@tubesandmore.com; http://www.tubesandmore.com**; Digi-Key Corp, 701 Brooks Ave S, Thief River Falls, MN 56701-0677; tel 800-344-4539, 218-681-6674, fax 218-681-3380; **http://www.digikey.com**; Fair Radio Sales Co, Inc, 1016 East Eureka St, PO Box 1105, Lima, OH 45804; tel 419-227-6573, 419-223-2196; fax 419-227-1313; e-mail **fairadio@wcoil.com**; **http://www.fairradio.com/**; Ocean State Electronics, PO Box 1458, 6 Industrial Dr, Westerly, RI 02891; tel 800-866-6626, 401-596-3080, fax 401-596-3590; RadioShack—see your local distributor. RadioShack.com L. P., 300 West Third Street, Suite 1400, Fort Worth, TX 76102; **http://www.radioshack.com/**; The Electronic Goldmine, PO Box 5408, Scottsdale, AZ; 85261; tel 800-445-0697; fax 480-661-8259; e-mail **goldmine-elec@goldmine-elec.com**; **http://www.goldmine-elec.com**.

[3]Charles Kitchin, N1TEV, "High Performance Regenerative Receiver Design," *QEX*, Nov/Dec 1998, pp 24-36. See also Charles Kitchin, N1TEV, "Regenerative Receivers: Past And Present," *Communications Quarterly*, Fall 1995, pp 7-26.

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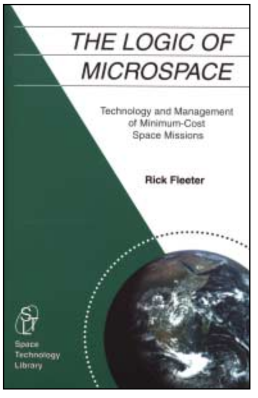
NEW BOOKS

THE LOGIC OF MICROSPACE



By Rick Fleeter, K8VK

Published jointly by Kluwer Academic Publishers and Microcosm Press. Available from Microcosm Press, 401 Coral Circle, El Segundo, CA 90245-4622; tel 310-726-4100; **http://www.smad.com**. *6×9 inches, 477 pages. Softcover. ISBN 1-881883-11-6. $29.95.*

Reviewed by Steve Ford, WB8IMY
QST *Managing Editor*

◊ The *Logic of Microspace* has nothing to do with Amateur Radio—and everything to do with Amateur Radio. Hams pioneered the concept of microsatellites—compact spacecraft designed to be deployed at minimal cost while offering flexible functionality. The results are orbiting overhead as you read these words. Several of the first Amateur Radio microsats launched almost 10 years ago are still very much alive and well.

Microsats have since moved into the commercial sphere with corporations, governments and even NASA embracing the concept. In fact, author Rick Fleeter, K8VK, is president and CEO of AeroAstro, a company that designs and builds microsats.

But we still haven't addressed the question of why you should be interested in reading *The Logic of Microspace*. There are two reasons: (1) To gain an education in the fascinating world of space technology in general and microsats in particular and, (2) because this book is a pure delight.

Rick Fleeter is one of those rare individuals who can not only explain technical topics to any audience, he can do so with highly effective humor. This gifted combination of talent makes *The Logic of Microspace* one of the most unusual science and technology books you'll ever read.

Like his previous work, *Micro Space Craft*, *The Logic of Microspace* is the kind of title that seems deliberately designed to hide the true content of the book. If you saw *The Logic of Microspace* sitting on a bookstore shelf, chances are you'd stroll right by without giving it much more than a glance. (Oh, another one of those boring academic snoozers!)

You couldn't be more wrong.

In *The Logic of Microspace* Fleeter takes complex topics such as rocket propulsion and orbital mechanics and explains them clearly, without patronizing. *The Logic of Microspace* eschews the stuffy traditions of academic and technical writing. (There isn't a "hitherto" or a "thus" to be found.) Instead, *The Logic of Microspace* is totally conversational and often downright hilarious. Fleeter's writing style is filled with contemporary references to pop culture (rock n' roll in particular). Imagine a technical book written by a tag team of Carl Sagan, P. J. O'Rourke and Hunter Thompson and you'll have a pretty good idea of what to expect with *The Logic of Microspace*.

A glance at some of the chapter sections will give you a sense of the "atmosphere:"

- Weather, Ecology And Another Proof of the Existence of God
- How Mother Nature is Cruel to Eight-Year-Olds
- A War Waged for the Sake of the Clueless (my personal favorite)

The Logic of Microspace is really three books in one. The first is a treatise on space technology and physics. The second is a fascinating examination of the politics, planning and psychology that underlies much of the work involved in aerospace projects. The third is the biggest surprise of all—a work of science fiction. The 94-page novella is titled "A Wrinkle in Microspace" and it is as compelling as anything you'll find on the fiction shelf of your local library.

Although it may not be obvious, Amateur Radio illuminates every page of *The Logic of Microspace*. Insatible technical and scientific curiosity is what drove Rick Fleeter to become a ham in the first place. That same muse guided him later to a career in aerospace. *The Logic of Microspace* is, in many ways, a testimonial to the fundamental "spirit" that brings us all to this hobby—and carries some of us, such as Rick Fleeter, much farther.

NEW PRODUCTS

CAPANALYZER 88A IN-CIRCUIT CAPACITOR TESTER

◊ The CapAnalyzer 88A allows testing of electrolytic and tantalum capacitors in-circuit by measuring the equivalent series resistance (*ESR*) and the dc resistance (*DCR*)—eliminating the need to desolder the component from the pc board.

The test instrument discharges the capacitor, checks it for low DCR, reads out the high-frequency ESR and allows you to quickly compare those readings with the industry standard values conveniently provided on a three-color chart on the front panel.

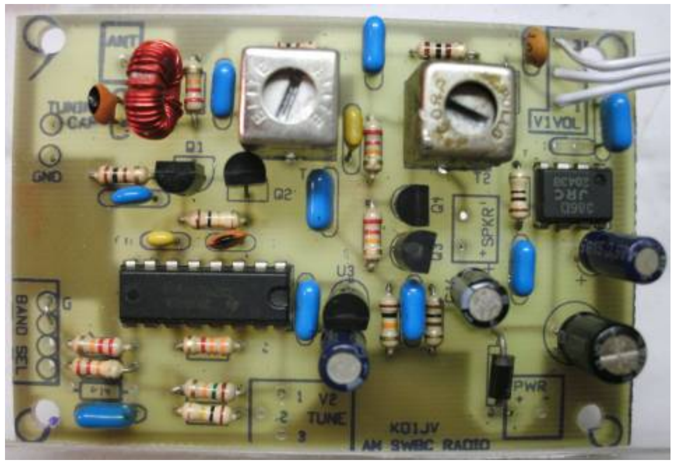
There's also a *QuickESR* mode to speed ESR-only testing and a 1- to 5-beep tone alert system that allows you to know the approximate ESR reading without having to avert your attention from the device under test.

The included tweezer-type probe allows easy one-handed testing of both normal and surface-mounted capacitors and uses coaxial cable instead of separate test-probe wires, insuring stable readings even on small capacitors.

The CapAnalyzer 88A is battery powered—an optional ac adapter is also available.

For more information, visit your favorite electronics distributor or contact Electronic Design Specialists, Inc, 4647 Appalachian St, Boca Raton, FL 33428; tel/fax 561-487-6103; **info@eds-inc.com**; **http://www.edsinc.com/**.

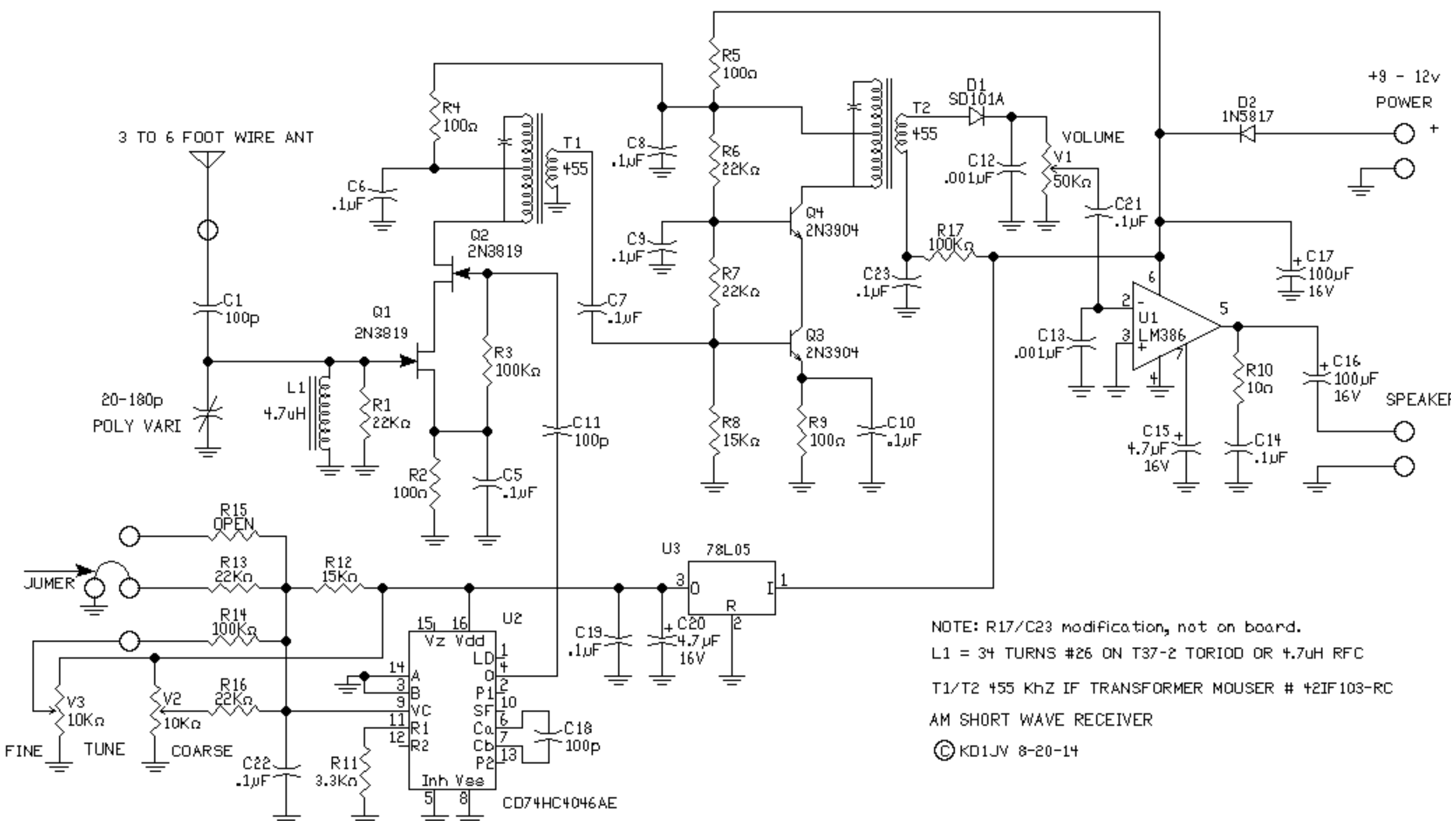
Simple, low cost AM SWBC Receiver



This project has been updated. This design was originally published 10 years ago (2004) and since then several parts have become discontiuned and no longer available. The part numbers for many of the parts have changed so they come up as "not found" when you go looking for them. Since FAR circuits recently made up some boards for this project, I decided it was time to update the information.

This AM Short Wave Broadcast Receiver is a reasonably simple, but effective design and can be built at low cost. It requires no adjustments to get to work and is more or less fool proof. This makes it a great beginners project, with little or no test equipment. The radio can be built for about $20.00, even if all new parts need to be bought. Many of the parts can be salvaged from an old AM/FM transistor or clock radio.

The radio will drive a small speaker to a comfortable volume. It will work with a short wire (3 feet or longer) or telescoping antenna. Tuning range is about 5.5 MHz to 10 MHz, using a coarse and fine tuning control. The radio can be powered by a 9 volt battery and draws about 21 ma of current. I would recomment using AA batteries or a small 9V AC adaptor to power the radio, as 9V radio batteries are expensive and won't last too long.



How it works:

The antenna is coupled into the mixer through C1, 100 pfd. The input to the mixer is tuned to about the receive frequency of interest by L1 and a poly-variable cap. The tuning cap can be a little hard to find as a new part, but can be salvaged from a dead or cheap AM/FM radio. (Poly-variables are available from qrpkits.com)

The mixer is an active stage using two JFETs in a cascode configuration. 2N3819's are shown, but just about any N channel JFET will work. The circuit was shamelessly borrowed from experimental Methods of RF Design" by W7OZI and co-anthers. This mixer exhibits about 13 dB of

conversion gain. It requires a large amplitude Local Oscillator drive, which makes directly coupling to the square wave output of the 74HC4046 VCO quite acceptable.

The output of the mixer is tuned to the IF frequency of 455 kHz by the IF transformer T1. This is coupled into a cascode amplifier consisting of Q2 and Q3. This amplifier basically combines a common emitter amplifier to which the input signal is coupled to, with a common base amplifier which adds additional gain, but keeps the amplifier quite stable. The output of this stage is again tuned with a 455 kHz IF transformer. The combination of the two IF transformers gives the radio some selectivity.

The AM signal is detected by a Shottky diode on the output of T2. A Shottky is used due to its low forward drop voltage, which reduces the level needed to detect a signal by at least 3 times over a silicon diode. The diode is connected to the volume control, which in turn goes to a LM386 audio amp. Forward bias was added to the detector diode to improve small signal sensitity and improves the audio quality. R17 supplies the bias and C23 by-passes the RF. These parts need to be added to the bottom of the circuit board.

The Local Oscillator uses the Voltage tuned R/C oscillator section of a 74HC4046 PLL. This part is capable of generating a signal up to about 30 MHz. C18 and R11 comprise the R/C part of the oscillator. The R/C oscillator isn't very stable and constantly bounces around a few 100 Hz. Fortunetly, the wide bandwidth of the IF and the nature of AM modulation is such that the instablility is not noticable to any great extent.

The original design was set up to just tune three SWBC bands and used a bank of three resistors selected by a switch to set the center of the tuning frequency to those bands. The TI chip tunes a wider frequency range so the voltages which need to be set for each band become farily close to each other, making it difficult to come up with standard values for the divider. Plus there is the problem of parts tollerances which will cause the exact voltages needed for a specific frequency to vary unit to unit.

The best way to solve this delema was simply to make continues tuning. Spaning large frequency range with a single turn pot makes for some very touchy tuning, so a fine tune control was added. Or you could use a 10 turn pot, but those are expensive. Trimmer resistors could have been used to set the center frequency for each band, but the board was not set up for that and now that boards have been made, too late to change.

WARNING: Not all 74HC4046s are created equal. The values shown are for the CD74HC4046N made by Texas Insturments (which is currently the only supplier of new through hole versions of this part). Parts made by a different manufacturer will require different values. Probably radically different values. The origninal CMOS 4046 parts will not work, as they have a much lower maximum operating frequency.

Construction:

Parts list and assembly drawings at bottom of page.

If you can make your own circuit boards, the layout and component location screen is avaiable as SWBC_PCB.pdf . A premade circuit board is also available from FAR Circuits for $5.00. (note, if you get the FAR board, there is a missing hole for one of the pins for T2 which you will have to drill).

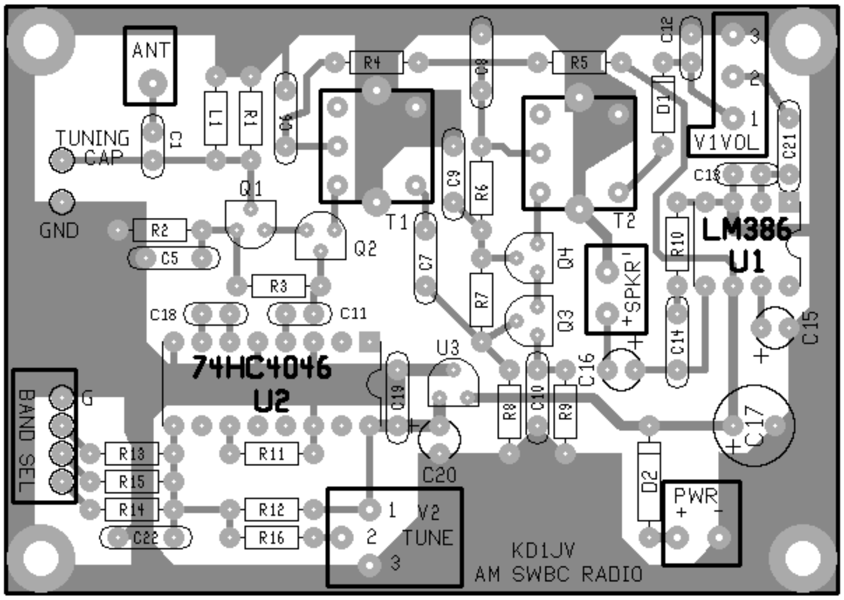
Assembly is straight forward. It is easiest to start with the resistors, then the IC's, then the caps and so on. Note that the lead spacing for the resistors is very tight for 1/4 W resistors. You may want to use 1/8 W instead.

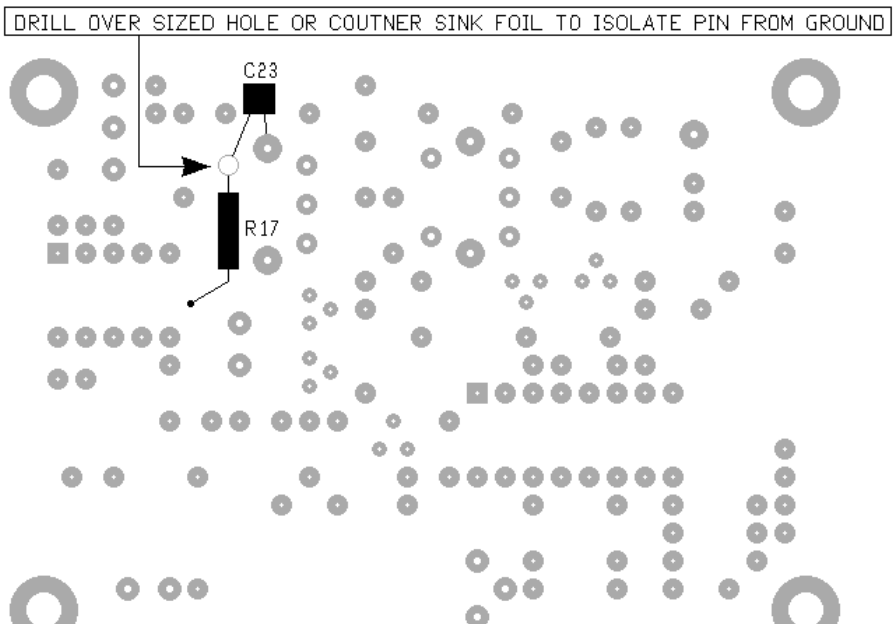
Adding some forward bias to the detector diode improves sensitivity and fidelity of the received signal. This is done be isolating the normally grounded pin of T2 secondary and adding a resistor between the pin and plus supply and adding a bypass cap between the pin and ground. Since the hole for this pin is missing from the board supplied by FAR curcuits, using a common 1/16" drill bit to make the hole should be big enough. Just be careful not to short to the foil around the hole when adding the components to the pin. You could also use an XACTO knife to cut the foil.

A frequency counter can be connected to pin 4 of U2, the 74HC4046. This is a 5 volt square wave. A 6 digit LED counter with programable IF offset can be bought direct from China for about $15US. This makes a nice digial dial, but draws an additional 90 ma. Set the dial for negative IF offset. In this mode, it will add the IF offset to the VFO frequency. Note that these counters clip the input to 600 mv with diode clamps which will load down the output of the '4046. In this case, add a series resistor of 3.3K or there abouts bewteen the coutner input and 4046 output.

The two IF transformers should come set close enough to the same frequency so they don't need adjustment. But if you must (and we must) try and peak the signals, adjust just one transformer and NEVER touch the other. Otherwise, you will chase the center frequency up and down the adjustment range of the coils!

The input tuning is sharp enough that it will require frequent re-peaking as the coarse frequency is tuned up and down the tuning range.





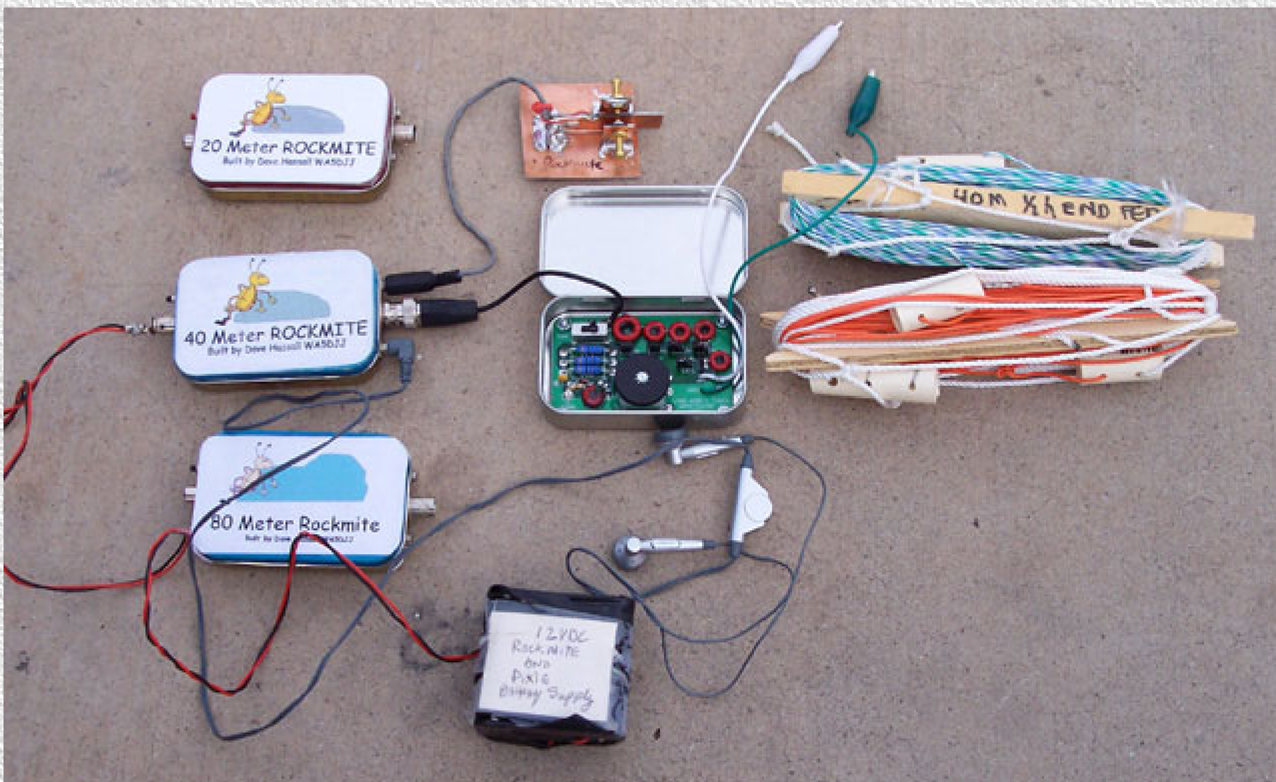
Parts list

Designator	Value	Mouser part number	Price as of 11/04	
C	poly-variable 20-180p	salvage from AM/FM radio	or www.qrpkits.con	
C5 - 10,14,19,21,22	.1 uFd (10 TOTAL)	80-C317C104M5U	$0.12 each	
C1, C11, C18	100 pFd NPO / C0G		$0.06 each	
C12,C13	.001 uFd	140-50P2-102K	$0.08 each	
C15,C20	4.7 uFd /16V	140-XRL16V4.7	$0.06 each	
C16/C17	100 uFd / 16V	140-XRL16V47	$0.06	
L1	4.7 uHy	434-22-4R7	$0.20	or 34T on T37-2
R8/12	15K 5% 1/4W	291-15K	$0.07 10 min order	($1.98 / 200!)
R2/4/5/9	100 ohm 5% 1/4W	291-100		
R3/14/17	100K 5% 1/4W	291-100K		
R1/6/7/13/16	22K 5% 1/4W	291-22K		
R10	10 ohm 5% 1/4W	291-10		
R11	3.3K 5% 1/4W	291-3.3K		
R15	NOT USED			
T1/T2	455 kHz IF transformer	42IF103-RC	$1.07each (need two)	
V1/V3	10K linear pot	31VA401	$1.25 (need two)	

V2	50K audio pot	31C501	$1.13	17mm with on/off sw
U1	74HC4046	595-CD74HC4046AE	$0.66	DIP-16
U2	LM386N	926-LM386N/NOPB	$1.01	DIP-8
U3	78L05	512-LM78L05ACZX	$0.27	TO-92
Q1/2	2N3819	610-2N3819	$0.86 each	TO-92
Q2/3	2N3904	512-2N3904BU	$0.19 each	TO-92
D1	SD101A	625-SD101A	$0.17	
D2	1N5817	615-1N5817	$0.14	
speaker	3" 8 ohm	253-4130	$1.91	

HOME

ROCKMITE STATION



In trying to shrink a normal amateur radio station into something that can be carried on a trip or into the field easily, I started buying the Rockmite kits put out by Small Wonders Labs. My goal was to be able to fit a complete traveling amateur radios station and all accessories needed to operate it into a 1 gallon ziploc plastic bag that could be thrown into a brief case, suitcase, or backpack. It had to have all the stuff to operate and be dependable enough to use.

The above picture all fits into a 1 gallon ziploc plastic bag and contains the following :
Rockmite transceivers for 80, 40 and 20 meters (I still have to buy the 30 meter one)
The KD1JV Altoids End Fed Antenna Tuner (sold by Doug Hendrix)
A 8 cell AA Battery pack that provides a handy 12VDC power supply
A pair of Walkman style Ear Buds with a inline volume control.
A PC Board CW Paddle (Plans for this key came from KD1JV's website)
A End Fed 1/2 wavelength antennas for 40 and 20 meters made out of #20 hookup wire (still have to make the 80 meter one)

I am still working with this station and it does have it's drawbacks in that the radios only operate on a single frequency. I also have KD1JV's ATS-3 all band transceiver and when I want to use more power, I put it in along with the rockmites. The ziploc bag is fuller but it still holds it all. Contacts are coming along as it is different than operating a normal QRO station and I am learning to be a better operator. This is a work in progress and will probably never be finished, but it does work and it is small and handy.

back to Dave's Ham Radio Projects page

CRYSTAL SET DESIGN 102

INTRODUCTION

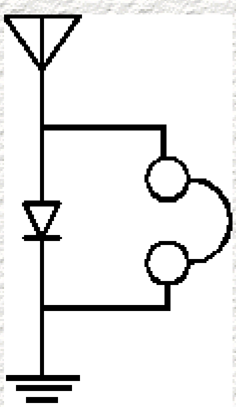
Welcome to Crystal Set Design 102. It is assumed that you've already completed the 101 level course elsewhere, and know, at least, something about electronics in general and crystal radios in particular. If not, hit the books. The stuff in your public library will get you started. The early chapters of the "Radio Amateurs Handbook" are especially concise and approachable.

I've been a little disappointed at the lack of meaningful crystal set technical information on the web and in current literature. This is my attempt to at least partially remedy this situation. This work is the result of about ten years part-time investigation of crystal radios from an engineering perspective. Serious development of passive receivers pretty much came to an end with the introduction of reliable vacuum tubes around 1920. A lot of crystal sets, both commercial and home brew, have been designed in the interim, but most are mediocre performers. So the mission turned out to be one of rediscovering the the secrets of the age when spark was king.

GETTING STARTED

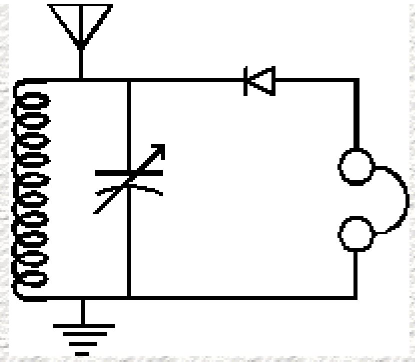
My approach is to build crystal radios out of quality vintage radio parts. They are available in great profusion at amateur radio "hamfests" and antique-radio meets (and in my garage). If you don't have access to these sources, I'd suggest you start at Radio Shack: Buy their Crystal AM Radio Kit, 28-177, for $6.99. This is actually not a bad crystal set, and it contains a coil, a variable capacitor, a germanium diode, and, most importantly, a reasonably sensitive high-impedance ear phone. You're also going to need an antenna. This generally means wire up in the air. The attic may be the next logical alternative. Apartment dwellers may be in trouble unless you're near an AM radio station, or can arrange a "stealth" antenna of some sort.. Again, if you don't (yet) have a junk box, get Radio Shack's Outdoor Antenna Kit, 278-758, for ten bucks. Wire has always been expensive, and hard to find retail, so keep your eyes open for bargains. Another RS item, that's almost indispensable, is a set of mini-alligator jumper cables, 278-1156, 10 for $3.99. These are how you make temporary "breadboard" hookups while experimenting with new circuits. You'll also want basic electronic hand tools and a soldering iron.

CIRCUITS



The simplest radio you can build is just a diode detector and a headset. With a reasonable antenna and ground you will hear the strongest stations, albeit all a once. This is not much of a radio. but it will give you some indication that you have enough signal strength to continue experimenting.

The primary problem with the above set is that it offers no selectivity. We'll solve this problem by building a tunable filter. This

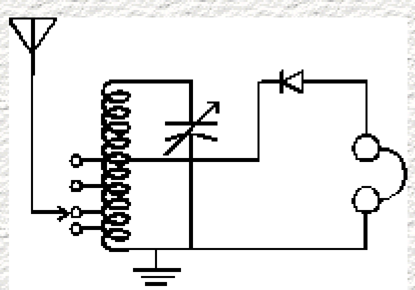


will generally consist of a coil and a capacitor forming a tuned circuit. Either the capacitor or inductor, or both need to be variable so circuit can be tuned to different stations. The classic values are 250 uH and 365 pF to tune the broadcast band. This is the basic crystal set schematic you'll find almost everywhere. It works better than just a diode, but has some serious short comings that are easily remedied.

THE IMPORTANCE OF IMPEDANCE MATCHING

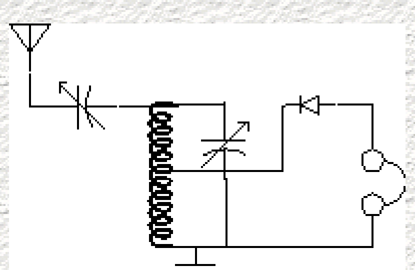
In a crystal set, all the audio power that arrives at your ear drum came from the distant transmitter. If the transmitter is hundreds of miles away, the amount of power captured by even a good antenna is reckoned in nanowatts . At each point in the set we must strive to transfer at least a reasonable percentage of the available power to the next stage. Perfect impedance matching is not necessary, don't fret over a 2 to 1 mismatch, but let's eliminate as many of the 10 to 1 and 100 to 1 mismatches as we can.

SINGLE TUNED SETS

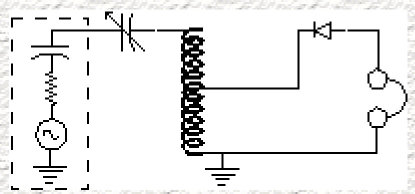


In the case of the simple set in the last example, lets do two things: Tap the antenna input "down" on the coil. The impedances of the antenna and tuned circuit will vary with frequency, so it's a good idea to provide multiple taps and a selector switch or movable jumper. As a starting point tap the coil at about 5%, 10%, 20%, and 50% of the total number of turns from the ground end of the coil. Secondly, connect the detector to the 50% tap. This does two things, both of them beneficial: It provides a better match to the detector when it's connected to the usual sort of crystal set headphone that has an impedance of about 10K ohms, resulting in a louder signal. It's also reduces the loading on the tuned circuit, increasing it's Q and consequently it's selectivity.

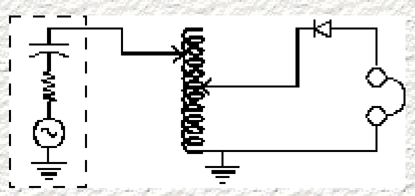
These improvements result in a better than average crystal radio. With 50-75 feet of wire up in the air, you should hear daytime 50KW stations out to 40-50 miles, and night-time skywave stations will come in form hundreds of miles away. This is essentially the circuit I arrived at for my Cub Scouts a few years back. (See *The Den Two Crystal Radio* in *Crystal Set Projects* published by The Xtal Set Society) You'll also notice it's almost exactly the same circuit used in the Radio Shack set



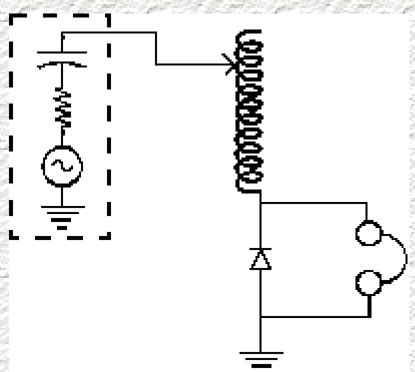
Another effective way to match the antenna to the tuned circuit is to use a variable capacitor as shown in the drawing. A cap in the 300-500 pF range is appropriate. Tune in a station then change the coupling and retune and see if there's an improvement. Some sets have the coupling capacitor in the ground lead instead of the antenna lead. Electrically it's the same thing, but sometimes it's more convenient for mounting and grounding and eliminating hand capacitance effects.



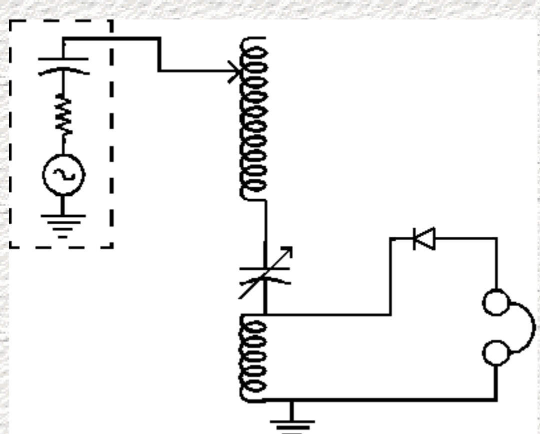
With the previous circuit, connected to a good sized antenna, you'll find you can set the tuning capacitor to it's minimum value, or even remove it completely and still get good performance. To understand how this "series tuned" receiver works, I've inserted the equivalent circuit of the antenna in the drawing. Any Macroni antenna less than a quarter wavelength long appears to be a capacitor in series with a small resistor, known as the radiation resistance of the antenna, and an RF voltage source. This is almost always the case as a quarter wavelength, even at the top of the broadcast band, is 187 feet. Our aim is to make as much RF current as possible flow from our antenna. When the series value of the antenna and tuning capacitors and the inductor are tuned to the frequency of interest, the inductive and capacitive reactance's cancel out, leaving only the DC resistance of the inductor. This results in maximum current flow in the tuned circuit, and maximum voltage applied to the detector. A receiver of this sort will usually require a variable inductor to cover the entire broadcast band. In such cases, keeping the detector connected to the optimal point on the coil presents challenges.



One classic variation on the series tuned receiver, known as the "two-slider tuner", dispenses with the tuning capacitor entirely. Instead a sliding contact on the coil varies the inductance in the antenna circuit. A second slider connects the detector at the best point on the coil. Total inductance should probably be the better part of a millihenry.



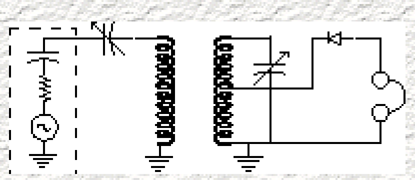
Yet another, historically common circuit, connects the detector in series with the variable inductor. This is not such a great idea from the standpoint of impedance matching, but it is simple. Series tuned sets all have difficulties with short antennas, because their capacity is low.



Another way to implement the series tuned set, that improves the match to the detector, is to connect the detector and headset across a second coil in the series circuit. For the broadcast band, this coil has a fixed value of approximately 80 uH. The variable capacitor is optional, especially if the larger inductor is continuously variable.

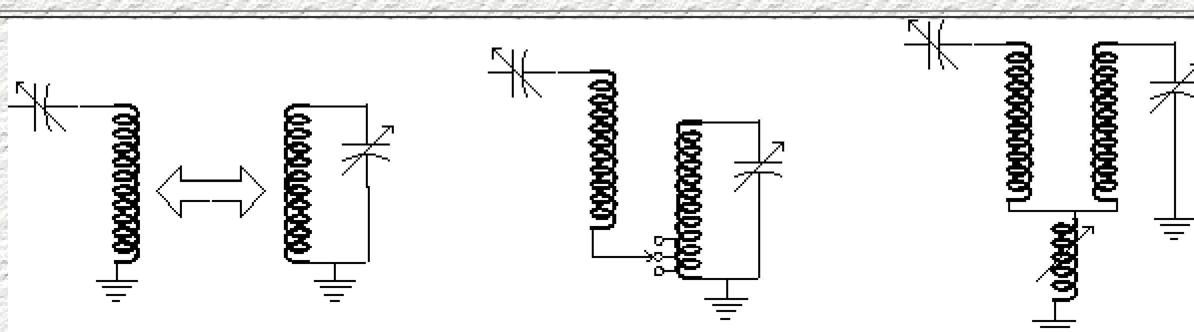
Single-tuned crystal sets, whether series or parallel tuned, leave a lot to be desired in terms of selectivity. Yes, the nose selectivity can be improved by increasing the Q of the tuned circuit, but the skirt selectivity remains hopelessly broad. The obvious solution is to use more than one tuned circuit. The point of diminishing returns is between 2 and 3 circuits for a crystal set due to cumulative losses and tuning difficulties.

THE TWO-CIRCUIT RECEIVER



The classic solution is the "two circuit" tuner. The antenna circuit is series tuned by a variable capacitor and an inductor, while the detector circuit is connected to a parallel LC circuit. The amount of mutual inductance, or coupling, between the primary and secondary circuit is generally made variable. This allows light coupling to be used to obtain the sharpest tuning, while increasing the coupling increases sensitivity at the expense of selectivity. This is essentially the same architecture used to great effect in the communication receivers of the wireless era. If you're seeking better performance for your crystal set this increased complexity is well worthwhile.

There are several way to implement variable coupling in the two-circuit set. The navy style "loose couplers" used a secondary coil that telescoped inside the primary. Other possible schemes include variable taps on the low end of the secondary coil, link coupling between the two coils, or the use of a small variable inductance common to both circuits.



Variable coupling schemes for two-circuit tuners.

ADDITIONAL DETAILS

The primary inductance will want to have a maximum value of about 500 uH to reach down to 530 KHz. However, a lesser value in needed to reach the 1600 KHz end of the band. I've been building coils with five or six evenly spaced taps. This lets you tune around for an optimum match to the antenna.

Install a DPDT switch to allow the primary circuit to be operated in a parallel-tuned mode: The input end of the primary capicator is grounded, and the antenna attached to the top of the coil. This allows effective operation with short antennas.

If a non-fixed detector is used in a double-tuned circuit, it's a good idea to include a buzzer to generate a local signal to adjust the detector. The circuit is a low-voltage mechanical buzzer, a battery, a push-button switch, and a one-or-two-turn link to the secondary coil. A low voltage relay with it's normally-closed contact wired in series with the coil is a good substitute for a buzzer.

HOME

QRPme

- Home

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- BIG Manhattan pack
- PocketPAL ver 2 tester
- Sudden Storm w/7 XTALS!
- Texas Topper w/5 band modules!

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- WBB kit mailed to your QTH
- FDIM 2017 Buildathon ..... (mailed to your QTH)

- STIX MePads/MeSquares panel
- STIX/MeP/MeS/MeT sampler
- 40th Anniversary TT2
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- A BRASS SET
- Miscellaneous Parts

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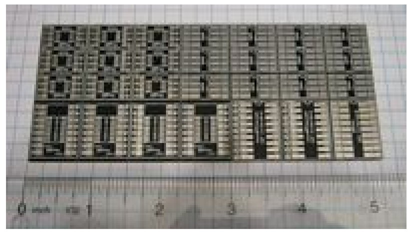
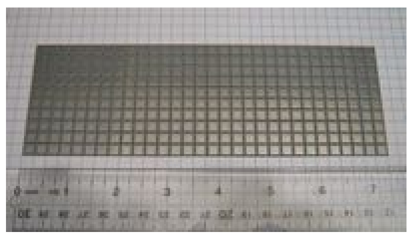
HOME BREW SUPPLIES from QRPme:

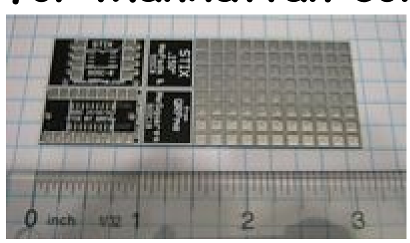


MePads. Paddyboards with IC patterns for Manhatten construction!



MeSquares. Nice tinned square pads for true Manhattan construction projects!

MeTubes. Vaccuum tube paddyboards for Manhattan construction!



STIX. Smaller squares than MeSquares & 2 SOICs panel!

MeP/MeS/MeT/STIX Sampler Scratchbuilder's Sampler pack

The Tuna Project Board. Build your own tuna can accessory item!.

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- Tuna can kit interconnect diagram

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- Special #1 PCB "Independence Day" Building Bundle
- Special #2 Manhattan Scratchbuilding Special
- Special #3 40m 7 Crystal Pack
- Special pcb stock for toner transfer technique
- Two Tinned Tunas (EZ Build)
- Sudden Storm Kit
- Rexwood 1000W Receiver Kit
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- 40m SUPER Tuna Band Module
- 30m SUPER Tuna Band Module
- 20m SUPER Tuna Band Module

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Holey Toids board. QRPme's 1st product, a drop in project board for mint tins!

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A PAIR of Solder Bots. TWO solder bots for double ended clamping action!

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Tip Cleaner. Soldering iron tip cleaner!.

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- Tuna Helper
- Texas Topper
- Tuna Topper][+
- Block_Toids
- Pocket PAL][Handy Dandy Hamfest parts Checker
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- Picnic Table Outlets Kit
- Picnic Table Outlets Upgrade
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- Island Cutter Kit
- Altoids Prototyping Kit
- Preparation T Kit
- Kids Kit#1 - Learn the Code
- Numerical Frequency Indicator
- Numerical RST Indicator
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- MeSQUAREs
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- Night Sender KEY
- Lobstercon Maine Bugs 2 Kit
- Match-less Dummy Load
- UK Bugs Kit
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- AXEme Picaxe Construction Kit
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- Match-less Audio OSC
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- Tuna Project Board
- Tuna Construction Zone - Tip Cleaner

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- Lil Squall Transceiver][
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- QRPme Kit of the Month Club - 3 Month Subscription
- 2014 FDIM Buildathon Kit
- Lil Squall 10m Band Module
- Sudden Storm 10m Band Module
- BCI Filter / MePad kit
- Micro80D
- SBSS
- HOLEY TOIDS!

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- Texas Topper][+ 5 band SPECIAL!
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- MeTubes
- MeTubes
- Quality Tuna Housing
- Hollow State Design Book & MeTubes Panel
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- Rockmite][40m Transceiver
- Rockmite][30m Transceiver
- Rockmite][20m Transceiver
- Rockmite][Accessory Parts kit
- Rockmite][Enclosure - LMB Gray/Blue
- Rockmite][40m Power/Efficiency Mod kit
- Rockmite][20m Power/Efficiency Mod kit
- Rockmite][40m Xtra Crystals pack
- MePads, MeSquares, MeTubes & STIX Sample Pack
- Maker Sender
- Maker Sender 6-pack
- Maker Sender 12-pack
- Rockmite][Enclosure - Hammertone Green
- Rockmite][Enclosure - BLACK & BLACK
- Rockmite][Enclosure - RED
- Rockmite][Enclosure - BLACK & RED

- Rockmite][Enclosure - BLACK & YELLOW
- Rockmite][30m Power & Efficiency Kit
- Rockmite][17m Transceiver Kit
- Rockmite][15m Transceiver Kit
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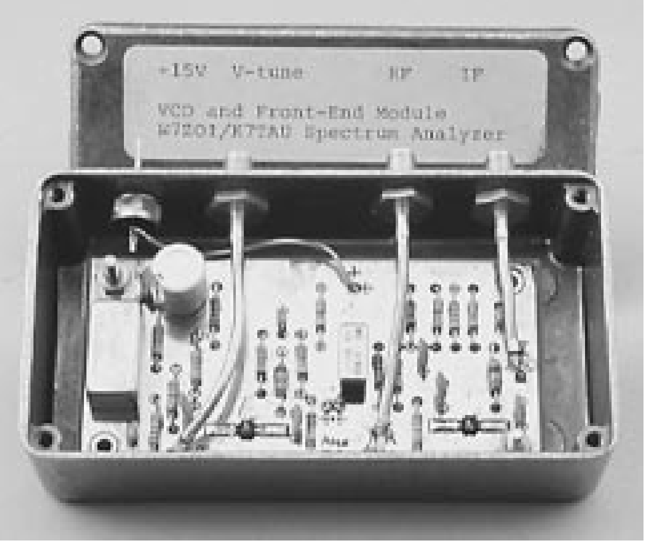
- Maker Faire Morrse Sender 2016 (box of 10)
- UKs BIGGEST Buildathon
- STIX MePads & MeSquares panel
- DX Custom Buildathon

- QRPme Christmas Stocking....TUBBY
- QRPme Christmas Stocking....SKINNY
- QRPme Christmas Stocking...QRPp
- Tuna RF Monitor
- FDIM Buildathon 2017
- FDIM 2017 Buildathon kit mailed to your QTH
- Lobstercon2017!
- Crystal Grinding Accessory Pack
- Duke City Hamfest Buildathon
- NEQRP Boxboro Buildathon
- Rockmite][SKINNY kit
- Sudden Storm 7
- Lobstercon2018!

By Wes Hayward, W7ZOI, and Terry White, K7TAU

A Spectrum Analyzer for the Radio Amateur—*Part 2*

Here are some examples of procedures you can use to become familiar with your new spectrum analyzer.



In Part 1,[14] we described the design and construction of a simple, yet useful spectrum analyzer. This installment presents some applications and methods that extend the underlying concepts.

Amplifier Gain Evaluation

One use for a spectrum analyzer is amplifier evaluation. We can illustrate this with a small amplifier from the test-equipment drawer—an old module that has been pressed into service for a variety of experiments. This circuit, shown in Figure 11, is used for illustration only and is not presented as an optimum design. It's a project that grew from available parts and may be familiar to some readers. The circuit uses four identical 2N5179 amplifier stages. A combination of emitter degeneration and parallel feedback provides the negative feedback needed to stabilize gain and impedance. (Ideally, construction and measurement of a *single* stage should precede construction of the complete amplifier.)

We began the experiment by setting the signal generator at a known power level, –20 dBm. (If a good signal generator is unavailable, you can easily build a suitable substitute.[15] We used a surplus HP8654A for most of these experiments.) With the generator and spectrum analyzer connected to each other through 50-Ω coax cable, we set the generator to 14 MHz with 10-dB attenuation ahead of the analyzer. The amplifier was not yet connected. We adjusted the analyzer's **IF GAIN** control for a response at the top of the screen. Using a resolution bandwidth of 300 kHz allows for a fast sweep without distortion. In our case, the second harmonic was only 26 dB below the peak response. However, when we added a 15 MHz low-pass filter, the second harmonic dropped to –57 dBc.[16] The third harmonic is well into the noise. (It is not unusual for a signal generator to be moderately rich in harmonics.)

Next, we inserted the amplifier between the signal generator and the analyzer, keeping the low-pass filter in the generator output. The on-screen signal went well above the top as soon as the amplifier was turned on. Decreasing the signal generator output to –51 dBm produced the same –20 dBm analyzer signal that we saw before the amplifier was inserted. The gain measured 31 dB.[17] Increasing the analyzer attenuation by 10 dB (for a reference level of –10 dBm) and increasing the generator output to –41 dBm produced the same gain, but a growing harmonic output. The second-harmonic response was now at –43 dBc and a third harmonic appeared out of the noise at –60 dBc.

We continued the process—moving both step attenuators produced an amplifier output of 0 dBm with second and third harmonics at –28 and –36 dBc, respectively. The next 10-dB step, however, didn't work as well, producing gain compression. With a drive of –21 dBm, the output was only +4 dBm, a gain of only 25 dB instead of the small-signal value of 31 dB.

Amplifier Intermodulation Distortion

Next, we measured intermodulation distortion (IMD). The setup for these experiments is shown in Figure 12. Two crystal-controlled sources[18] at 14.04 and 14.32 MHz are combined in a 6 dB hybrid combiner (return-loss bridge),[19] applied to the 15 MHz low-pass filter and a step attenuator having 1 dB steps. This composite signal drove the amplifier, with its output routed to the spectrum analyzer. For this measurement, we dropped the resolution bandwidth to 30 kHz. (The video filter was turned on and the sweep rate reduced until the signal amplitude was stable.) The analyzer's attenuator, set for a reference level of –10 dBm at the top of the screen, was confirmed with a calibration signal from the signal generator. We adjusted the **IF GAIN** to compensate for changes in analyzer bandwidth and for log-amplifier drift.

The output of the two-tone generator system was adjusted to produce a spectrum analyzer response of –10 dBm per tone. The IMD responses were readily seen, now 47 dB below the desired output tones. The output intercept is given by

$$IP3_{out} = P_{out} + \frac{IMDR}{2}$$

where P_{out} is the output power of each desired tone (–10 dBm) and IMDR is the intermodulation distortion ratio, here 47 dB. The output intercept for this amplifier measured +13.5 dBm. This is well in line with expectations for such a design.

When performing IMD measurements, it's a good idea to change the signal level while noting the resultant performance. Dropping the drive power by 2 dB should cause a –2 dB response in the desired tones, accompanied by a 6 dB drop in distortion-product tones. The output intercept

[14]Notes appear on page 40.

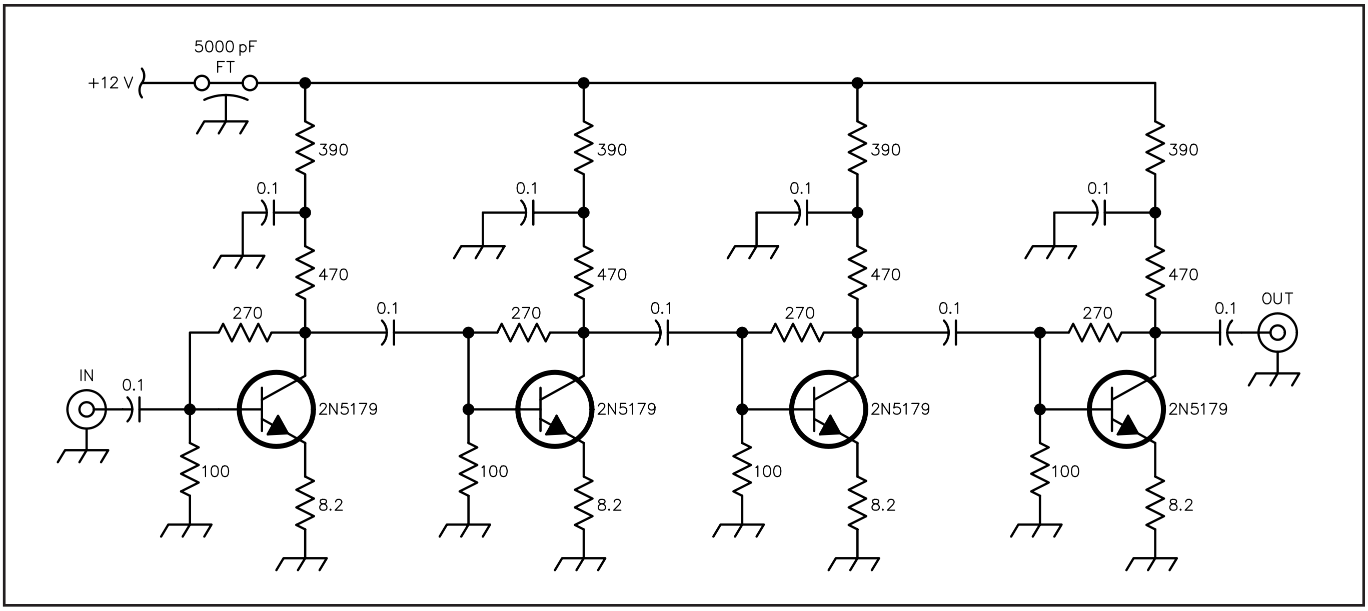


Figure 11—Sample wideband amplifier used to illustrate amplifier measurements.

should remain unchanged.

The IMD in the preceding example was 47 dB below the desired output tones, a value that we obtained by simply reading it from the face of the 'scope, possible because we use a log amplifier that has moderate log fidelity. If the log amplifier was not as accurate as it is, we could still get good measurements. In this example, you would note the location of the distortion products on the display. Then, using the step attenuator, decrease the desired tones until they are at the noted level. The result would be –47 dBc for the distortion level, a measurement that depends solely on the accuracy of the attenuator. This illustrates the profound utility of a *good* step attenuator, an instrument that can be the cornerstone of an excellent basement RF laboratory.

During the third-order output-intercept determination just described, we assumed that the distortion was a characteristic of the amplifier under test. This may not be true. It is important to determine the IMD characteristics of the spectrum analyzer used for the measurements before the amplifier measurements are fully validated. Specifically, for results to be valid, the input intercept of the analyzer should be much greater than the output intercept of the amplifier under test.

The spectrum analyzer input intercept is easily measured with the same equipment used to evaluate the amplifier. The two tones are applied to the analyzer input with no attenuation present at the analyzer front end. Then, the input tones are adjusted for a full-screen response. In this condition, there should be no trace of distortion. Although this is generally an adequate test, it *does not* establish a value for the input intercept. To do that, we must overdrive the analyzer, using signals that exceed the top of the screen.

The following steps were used to measure the analyzer input intercept:

• We calibrated the analyzer for a reference level of –30 dBm with a 30-kHz resolution.

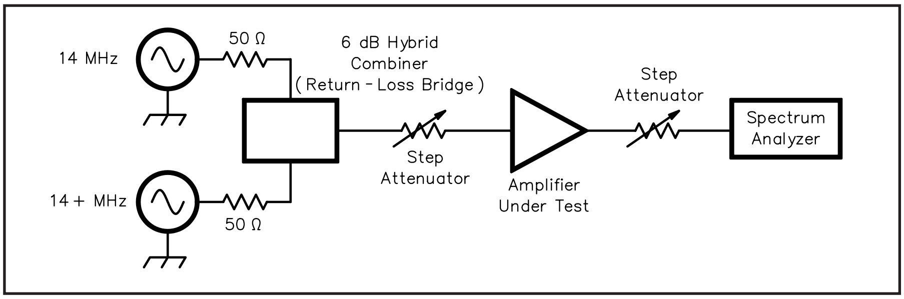


Figure 12—Equipment setup for evaluation of amplifier intermodulation distortion.

• Confirmed the lack of on-screen distortion with two tones at the reference level.

• Increased the drive of each tone by 10 dB to provide a pair of –20 dBm tones to the analyzer. This higher-than-reference-level input produced distortion products 66 dB below the reference level, or –96 dBm. The input signals producing this were each –20 dBm, so the IMD ratio is (–20) – (–96) = 76 dB. Following the earlier equation, the input intercept was +18 dBm.

• A 2-dB drive increase produced the expected 6-dB distortion increase. If this had not occurred, distortion measurements under overdrive would be suspect. The +18-dBm value seems to be a good number. This analyzer generally seems happy with signals 20 dB above the top of the screen, but not much more.

The intercept for the analyzer with attenuation in place is the measured value with no pad plus the attenuation. Hence, with 20 dB of attenuation, the input intercept will be +38 dBm, and so forth.

Return-Loss Measurements

The next amplifier characteristic that we measured was the input impedance match, or return loss, performed with the setup shown in Figure 13. With the signal generator set for a 14-MHz output of about –30 dBm, we set

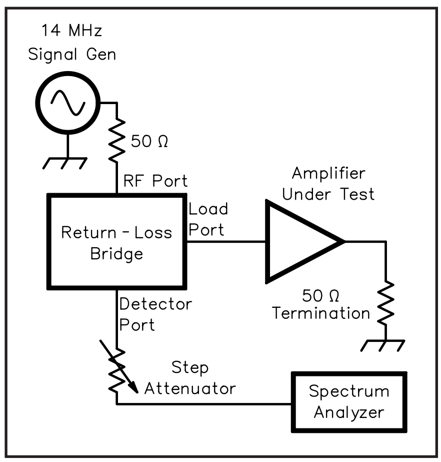


Figure 13—Test setup for impedance-match measurements with return-loss bridge.

the analyzer for full-scale response with the **LOAD** port of the return-loss bridge open circuited. Placing a 50-Ω termination momentarily on the **LOAD** port, produced a 38-dB signal drop. This is a measure of the bridge directivity. A 38-dB directivity is more than adequate for casual measurements.

Then, we removed the termination from

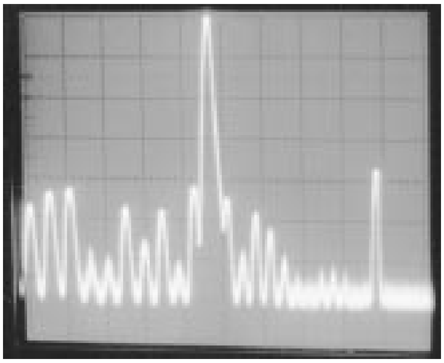


Figure 14—Output of a typical QRP transceiver kit. The 1-W plus output at 7 MHz is the dominant signal; all others are spurious outputs more than 40 dB down, currently meeting FCC specifications.

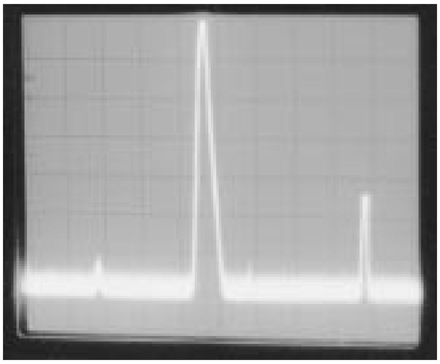


Figure 15—Output of a simple homemade QRP rig. The desired signal is the large pip at the center of the trace. Two measurable spurious responses exist, one to the left and one to the right of the main signal. The response to the left is 3.5 MHz feedthrough from the VFO at –64 dBc; the response to the right of the desired signal is a second harmonic at –44 dBc.

the bridge and placed it on the amplifier output. A short length of cable connected the bridge load port to the amplifier input with power applied to the amplifier. The result was a response 20 dB below the top of the display; 20 dB is the return loss for the amplifier input, an excellent match for a general-purpose amplifier.[20] The match improved slightly when the output load was removed, an unusual situation.

The next variation measured the output match for the amplifier. The load was transferred to the amplifier input and the cable from the bridge **LOAD** port was moved to the amplifier output, producing a reading 15 dB below the screen top. This match was virtually unchanged when the input termination was removed. The weak dependence of both amplifier return losses is the result of a four-stage design. A single-stage feedback amplifier will have port impedances that depend strongly on the termination at the opposite port.

The –30 dBm drive from the generator provides an available power of –36 dBm from the bridge **LOAD** port. This is low enough that the amplifier is not over-driven. The match measurements should be done at a level low enough that the amplifier remains linear. In this case, we saw no difference in the results with drive that was 10 dB higher.

When performing return-loss measurements—and indeed, most spectrum-analyzer measurements—it is wise to place at least 10 dB of attenuation ahead of the spectrum-analyzer mixer. When this attenuation is switched in, the reference level changes from the top of the screen to a point down screen a bit. Return loss is then measured as a decibel difference with regard to the new reference.

Antenna Measurements

It is interesting to look at some other impedance values while the return-loss bridge is attached to the signal generator and spectrum analyzer. The obvious choice is the station antenna system, especially if it is connected through a Transmatch. Playing with the tuning will readily demonstrate that the return-loss bridge and sensitive detection system will allow adjustments to accuracy unheard of with traditional diode detector systems. Although such tuning accuracy is not needed in a normal antenna installation, it is interesting to see what *can* be measured when the need does arise.

Transmitter Evaluation

Another obvious application for a spectrum analyzer is in transmitter evaluation. Figure 14 shows the output of a typical QRP transceiver kit. The 1-W plus output at 7 MHz is the dominant signal, with all others being transmitter spurious outputs. All spurs are more than 40 dB down, which meets current FCC specifications. On the other hand, significantly better performance is easily obtained, especially if the builder has the facilities to measure them. Figure 15 is a photograph of a simpler QRP rig with two measurable spurious responses. One is the 3.5-MHz feedthrough from the VFO at –64 dBc; the second is a harmonic at –44 dBc.

The output available from a typical QRP rig (and certainly higher power rigs) is enough to damage the spectrum-analyzer input circuits. Attenuators that we generally build are capable of handling 0.5 to 1 W input without damage, while commercial attenuators are rated at from 0.5 to 2 W input. The mixers used in this analyzer can be damaged with as little as 50 to 100 mW signals. Two methods can be employed to view the output of a high-power transmitter without causing damage to the spectrum analyzer. In one, the transmitter output is run through a directional coupler with weak coupling to the sampling port—perhaps –20 to –30 dB. The majority of the output is dissipated in a dummy load. The second method uses a fixed, high-power attenuator. Figure 16 shows an attenuator that will handle about 20 W while providing 20-dB attenuation. The design is not symmetrical.

Spectrum Analysis at Higher Frequencies

Although the 70-MHz spectrum analyzer is extremely useful, we constantly wish that it covered higher frequencies. Not only do we want to experiment on the VHF and UHF bands, but we need to examine higher-order harmonics of HF gear. One method we can use with a regular receiver is a converter, usually crystal controlled. The same can be done with a spectrum analyzer, although crystal control is not needed. We can build a simple block converter, consisting of nothing more than a 100 to 200 MHz VCO (just like that used in the analyzer) and a diode ring mixer. A Mini-Circuits POS-200 VCO with a 3 dB pad will directly drive a Mini-Circuits SBL-1 or TUF-1 mixer to produce a block converter with a nominal loss of 10 dB. (One of the spectrum analyzer front-end boards could be used, with slight modification, for the block converter.)

This block converter allows analysis of much of the VHF spectrum. With the converter VCO set at 100 MHz, frequencies from 100 to 170 MHz are easily studied. The 70 to 100-MHz image is also available—it can also lead to confusion, as a few minutes with a signal generator will demonstrate. With the converter VCO up at 200 MHz, the 200 to 270 MHz spectrum is also available. Clearly, there is nothing special about the particular VCO used in the converter. All that is required to convert other portions of the low UHF spectrum to the analyzer range is a different VCO, and perhaps, a higher-frequency mixer. We will soon build similar block converters to allow analysis of the 432-MHz area. One of the popular little UHF frequency counters is quite useful with these converters. The block converters should be well shielded and decoupled from the power supply.

Even without the analyzer, the block converter is a useful tool. For example, it can be used with a 10 MHz LC band-pass filter and an amplifier to directly drive a 50-Ω-terminated oscilloscope. This can serve as a sensitive detector for the alignment of a 110-MHz filter.

As useful as the block downconverter is, it has image-response problems that can greatly confuse the results. The preferred way to get to the higher frequencies is with a spectrum analyzer—just like the one we have described—but having higher-frequency oscillators and front-end filters. If you're careful, you can build helical resonator filters for the 500-MHz region, or higher, with sufficiently narrow selectivity to allow a second conversion to 10 MHz. A more practical route uses a third IF. Such a triple-conversion analyzer is shown in Figure 17, where a 1 to 1.8 GHz VCO moves signals in the 0 to 800-MHz spectrum to a 1 GHz IF. This signal is still easily amplified with available monolithic amplifiers. Building a 1 GHz filter should not be too difficult, for a narrow bandwidth is not required. A bandwidth of 20 or 30 MHz with a three-resonator filter would be adequate. The resulting signal is then heterodyned to a VHF IF (such as 110 MHz) where the remaining circuitry is now familiar.

Clearly, there are several ways to attack the project. Recent technology offers some help in the way of interesting band-pass filter structures, as well as high-performance, low-noise VCOs. Time spent with some cata-

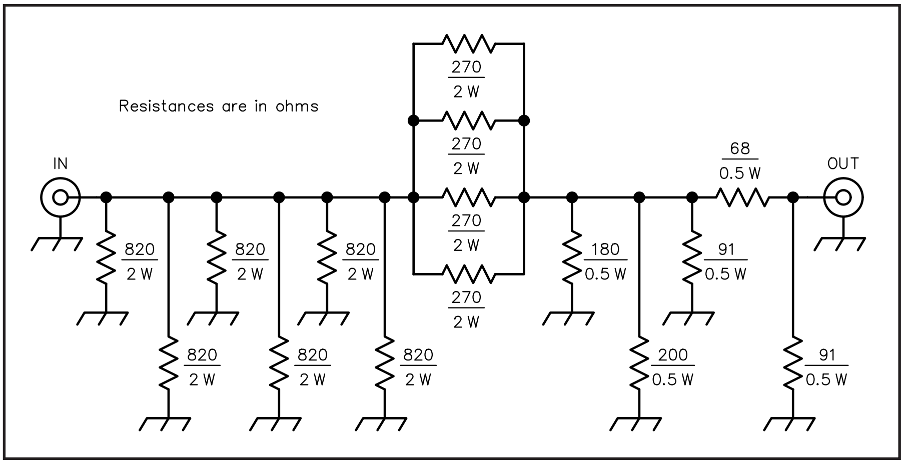
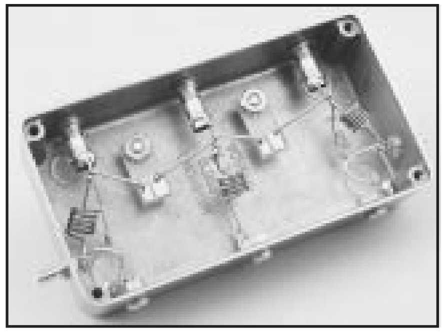


Figure 16—A 20-W, 20-dB attenuator for transmitter measurements.



An inside view of a prototype VHF band-pass filter. See Figure 7.

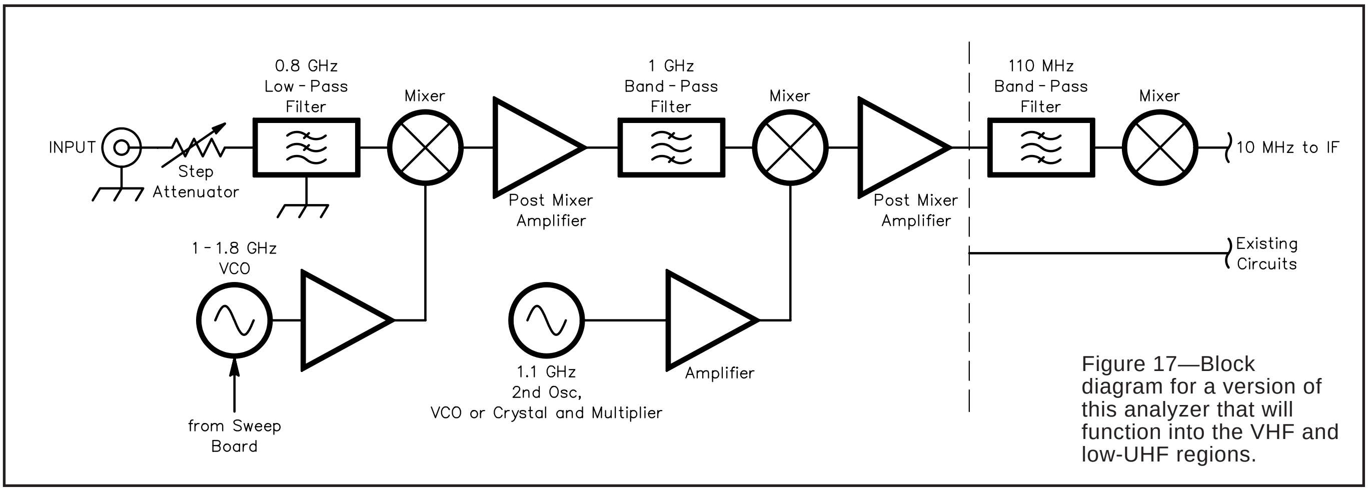


Figure 17—Block diagram for a version of this analyzer that will function into the VHF and low-UHF regions.

logs and a Web browser could be very productive in this regard. Just as important is the experience that the lower-frequency analyzer will provide. Not only is it the tool (perhaps supplemented with block converters) that is needed to build a higher-frequency spectrum analyzer, but it is the vehicle to provide *the confidence* needed to tackle such a chore.

Summary

This analyzer has been a useful tool for over 10 years now. It was a wonderful experience and fun to build HF and VHF CW and SSB gear with the "right" test equipment available. We have built special, narrow-tuning-range analyzers to examine transmitter sideband suppression and distortion. The equipment uses the same concepts presented.

There are many ways that this instrument can grow. One builder has already breadboarded a tracking generator. (Let's see that in *QST*!—*Ed.*) Many builders will want to interface the analyzer with a computer instead of an oscilloscope. A recent *QST* network analyzer paper suggests circuits that may provide such a solution.[21]

A recent *QST* summary of WRC97[22] outlines new specifications regarding spurious emissions from amateur transmitters. Generally, the casual specifications that we have enjoyed for many years are being replaced by new ones that are more stringent—and more realistic in safeguarding the spectral environment and reflecting the sound designs that we all strive to achieve. Equipment such as the spectrum analyzer described here can provide the basic tool needed to meet this new challenge.

Acknowledgments

Many experimenters had a hand in this project and we owe them our gratitude. Jeff Damm, WA7MLH, and Kurt Knoblock, WK7Q, built versions of the analyzer and have garnered several years of use with them. Their experiences have been of great value in our efforts. Barrie Gilbert of Analog Devices Northwest Labs suggested the AD8307 log amplifier and provided samples and early data needed for evaluation measurements. Many of our colleagues within the Wireless Communications Division at TriQuint Semiconductor have helped us with filter measurements: Thanks go to George Steen and to Don Knotts, W7HJS. Finally, special thanks go to our colleague in the receiver group at TriQuint, Rick Campbell, KK7B, who provided numerous enlightening discussions and suggestions regarding the preparation of the paper and the role of measurements in amateur experiments.

Notes

14 Wes Hayward, W7ZOI, and Terry White, K7TAU, "A Spectrum Analyzer for the Radio Amateur," *Part 1, QST*, Aug 1998, pp 35-43.

15 The wide-range oscillator presented in Fig 68, Chapter 7 of *Solid-State Design for the Radio Amateur* (Newington: ARRL, 1997) is still intact and still often used.

16 The term dBc refers to dB attenuation with respect to a specific *carrier*.

17 Formally, this is the transducer gain, or 50-Ω insertion gain. There are many different parameters that are called "gain."

18 The signal sources used are updated versions of the circuits shown in Fig 66, p 168, in the Note 15 referent.

19 See page 154, *Solid-State Design for the Radio Amateur*.

20 A 20-dB return loss corresponds to a voltage reflection coefficient of 0.1, or an SWR of 1.222. See Wes Hayward, W7ZOI, *Introduction to RF Design* (Newington: ARRL, 1994), p 120.

21 See, for example, Steven Hageman, "Build Your Own Network Analyzer," *QST*, Jan 1998, pp 39-45; *Part 2*, Feb 1998, pp 35-39.

22 Larry Price, W4RA, and Paul Rinaldo, W4RI, "WRC97, An Amateur Radio Perspective," *QST*, Feb 1998, pp 31-34. See also Rick Campbell, KK7B, "Unwanted Emissions Comments," Technical Correspondence, *QST*, Jun 1998, pp 61-62.

◊ Please refer to Wes Hayward, W7ZOI, and Terry White, K7TAU, "A Spectrum Analyzer for the Radio Amateur—*Part 2*, *QST*, Sep 1998, p 40, Fig 16. The six 2-W input resistors for the 20-dB pad should be 620 Ω units, not 820 Ω as originally specified.—*Wes Hayward, W7ZOI (tnx EA2SN)*

Phased-Array Demonstrator

Figure 1: Demonstrator for the functionality of a phased array antenna

The **phased array demonstrator** is a simple training device, designed to use in a classroom. With the help of this device can be demonstrated practically how a phased-array antenna works.

An oscillator transmits with less power over a group of four Yagi antennas in free space in a free ISM frequency band (***I**ndustrial, **S**cientific and **M**edical band*). Here was chosen a frequency between 2.40 – 2.48 GHz. The resultant power flux density from the antennas in the space can be measured by a commercially available high-frequency analyzer. The direction of maximum radiation can be thus determined.

An electronic phase shifter which is controlled by a static voltage may change the phase of each individual radiator to 45, 90, or 135 degrees. In total, this results in swiveling the direction of the radiations maximum by about 16 degrees to the left or (the other switch position) to the right. The far field of the antenna starts at a distance of about 3 to 4 m. Here the to measured radiation is very weak yet, and it is measured in microwatts per square meter. Incidentally it may be pointed out that the by the analyzer received power decreases with the square of the distance (Free-space path loss). If a direction with maximum power density was found, so the direction of the radiation can be changed using a changeover switch, so that the instrument cannot indicate any value.

The commercial high-frequency analyzer uses a very broadband calibrated antenna. With this antenna can be measured the radiation caused by the mobile phones of the students too. In order to prevent this falsifying the measuring result by interference, a narrow-band Yagi antenna with high directivity has been developed for this instrument. However, this additional measurement antenna is not calibrated. Therefore the displayed by the meter values can be compared only as relative values with each other.

Figure 2 shows the swiveling principle: one of the outer antennas has no phase shift and serves as a reference. If no phase shift would act, so the sum signal would show approximately in the geometric direction. The other antennas receive a gradually stepped value for the phase shift now. This phase shift can be a delay only, therefore the negative sign. The individual antenna diagrams now add up to the shown in Figure 2 overall diagram. Because of the phase shifts this diagram is now tilted by 16 degrees to the right. Such electronic swiveling can be made extremely fast: faster than any motor could rotate this antenna (and faster as you can set the switch).

This specialized training device has been developed by Radartutorial. The construction and distribution is performed by Köster Systemtechnik (Germany).

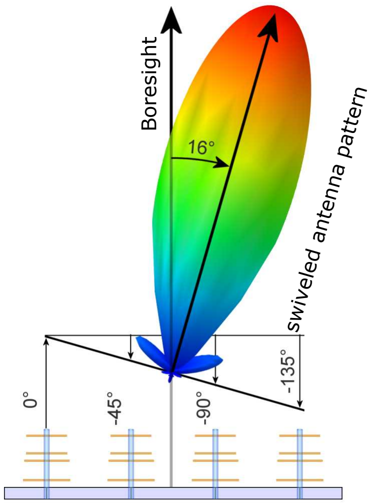


Figure 2: Principle of the antenna pattern swiveling in phased array demonstrator

"The 'Tenna Dipper"

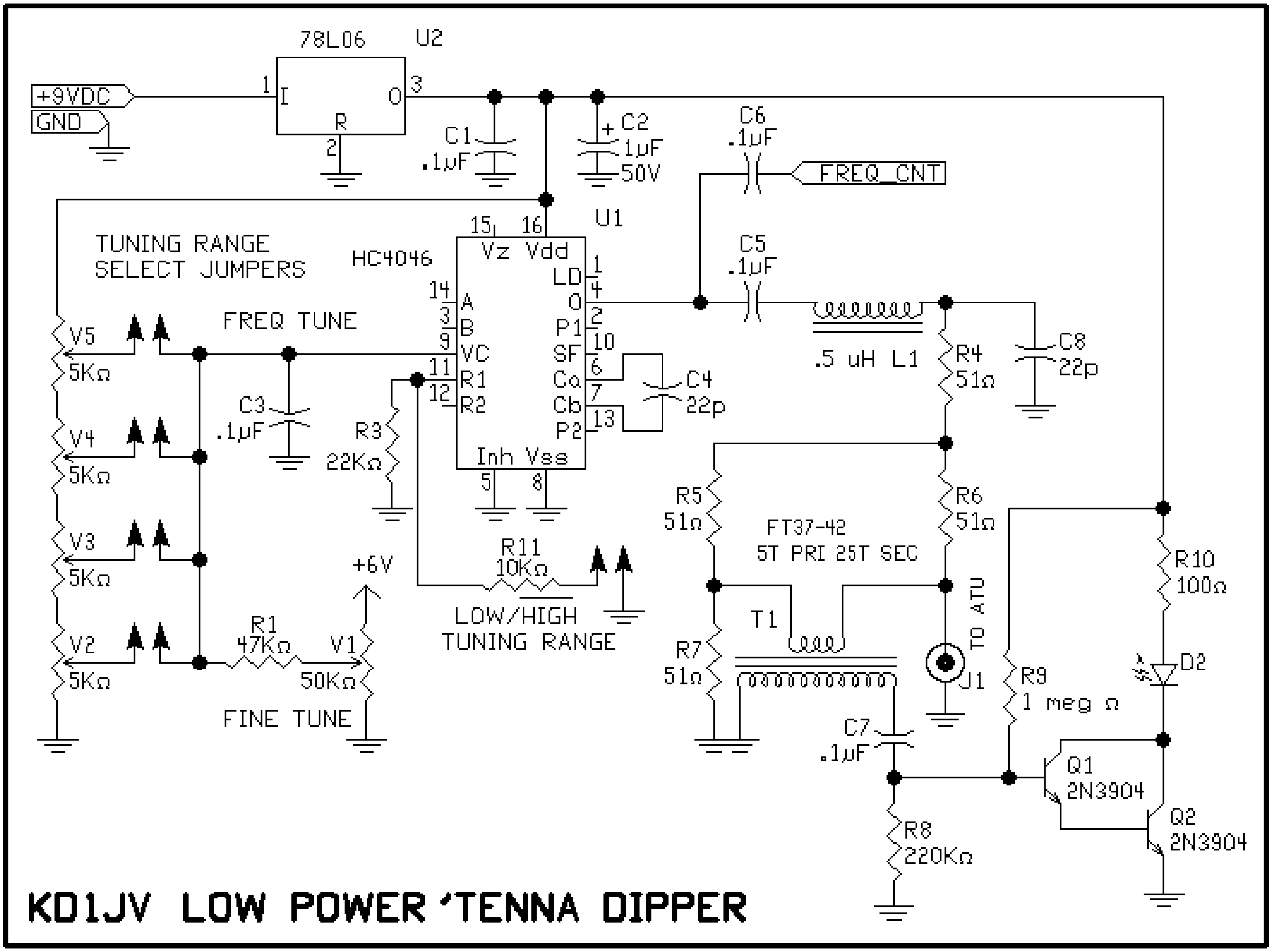
A Low Power Antenna Analyzer

and ATU Tuning Aid

Using just a few mw of output power, this circuit is used to find the 50 ohm resonance frequency of antennas or can be used to adjust an Antenna Tuning Unit for 50 ohm match, without generating QRM. The unit is powered by a 9 volt battery and a Frequency counter is required to know where the oscillator is tune to.

The output match indicator is a LED. The LED is off when the bridge is in balance and gets brighter when the bridge goes out of balance. Therefore, when using to adjust an ATU for 50 ohm match, one would adjust the ATU until the LED goes out. This circuit can be built on a small circuit board and uses little power, so is practical to take into the field

The " 'Tenna dipper" consists of a wide range voltage tuned oscillator, a 50 ohm resistive bridge and a sensitive defector circuit. Shown below is the circuit built on a 2" x 2" board, which is small enough to fit in an Altoids tin, along with a 9V battery.



The R/C oscillator section of a 74HC4046 PLL/VCO chip is used as the frequency source. The oscillator is tuned by the voltage on pin 9. A bank of four trimmer resistors is used to select tuning "bands" by the use of SIP pins and shorting blocks. DIP switches could be substituted. These trimmers can be used to preset the frequency to center it in one of four ham bands. The fine tune control is used the trim the frequency. If none of the jumpers are in place, the fine tune can be used to tune the oscillator over it's entire range, though with a single turn pot, it will be touchy.

With the 22K R3 value, the stable tuning range of the oscillator is about 2.5 to 22 MHz. To extend the stable tuning range, a second resistor, R11 is put in parallel with R3 and makes the stable tuning range about 7 to 40 MHz.

Here are the tuning ranges of the trimmers. The range of the fine tuning control varies with which trimmer is selected, but is generally a MHz or two.

Trimmer	W/O R11 jumper	with R11 jumper	
V2	2.5 to 4.8 MHz	7 to 13 MHz	
V3	5.0 to 8.5 MHz	13 to 21 MHz	
V4	8.6 to 12.3 MHz	21 to 27 MHz	
V5	12.5 to 22 MHz	27 to 40 MHz	

The upper frequency limit of the oscillator depends on who made the chip. One's made by Phillips and Harris should be able to go to 40 MHz. Ones made by Fairchild will crap out about 20- 21 MHz. Harris parts (CD74HC4046AE) can be found at Digi-Key and Mouser. The value of R9 may have to be trimmed depending on the chip used.

The output of the VCO directly drives the bridge through a VHF Low Pass Filter and then a 51 ohm resistor. Directly driving the bridge from the VCO ensures a constant drive level, which is difficult to achieve using a wide band amp without complicated frequency compensation.

Because of the low level of drive supplied to the bridge, a step up transformer is connected across the bridge output to provide passive gain. The output of the transformer is further amplified by a darlington transistor amplifier consisting of Q1 and Q2. R9, a 1 Meg ohm resistor provides a little bias voltage, but not quite enough to turn the amplifier on. In this way, the LED will go off if there is no input signal, yet keeps it sensitive to small input signals from the bridge.

There is no need for DC rectification of the RF signal being amplified by the darlington array. The LED provides an effective visual indication of the current flowing in the collector. The larger the input signal, the brighter the LED. This eliminates the "dead zone" produced by a diode rectifier which makes finding an exact null of the bridge impassable to achieve. It is also possible to put a meter across R10, if one so desires.

In order to know what frequency the oscillator is tuned to, one must connect up a frequency counter. You might only need to use this once to set the trimmers for each ham band you want to use. Then you would use the fine control and spot the frequency with your receiver. If your trimming or finding the resonant frequency of an antenna, then you'd need a counter connected to find the dip frequency.

Operation:

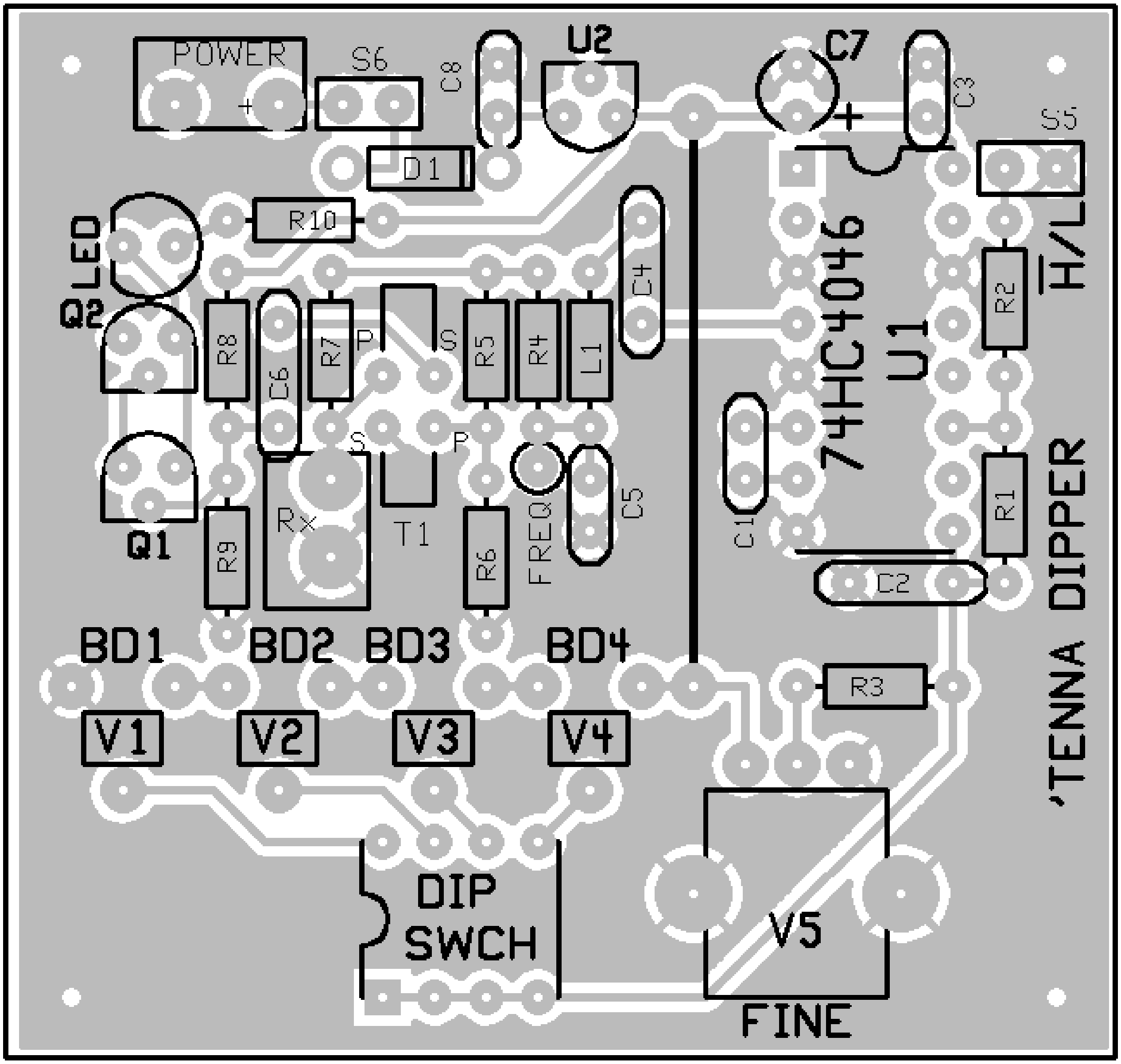
For finding the resonant frequency of an antenna, simply connect the antenna lead to J1 and sweep the frequency until the led goes out. If the LED can not be made to completely go out, then there is some reactive component to the impedance seen by the bridge.

For adjusting an ATU, connect the bridge to the input of the ATU and set the frequency to where you wish to operate. Now adjust the ATU to make the LED go out.

Although the oscillator isn't real stable, this unit is also handy as a general purpose signal generator.

Printed circuit board layout:

Several Hams have recently requested a board layout, so here it is. Parts placement are shown in the diagram below. Part numbers don't match those used on the schematic in a number of places, but I think you can figure it out. I don't want to spend the time making them match at this time. This board uses a four pole DIP switch for selecting band trimmers instead of jumper pins, which is easier to use and no jumper blocks to loose. Note that there is one point to point jumer, indicated by the black line. This connects power to the tuning resistors so that the ground plane is not broken. Down load a pdf file with the to scale board layout by clicking HERE. The layout is a through board view, suitable for printing directly on toner transfer film.



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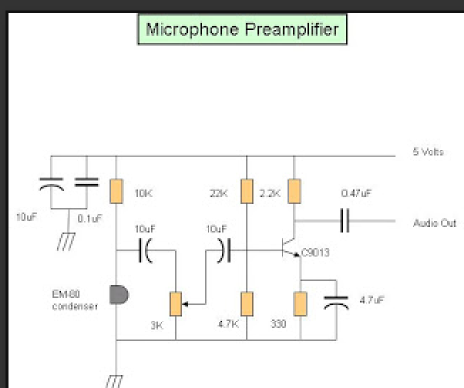
All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Tuesday, November 10, 2009

Microphone Preamplifier



Another weekend project is this microphone preamplifier which came from my new book Hints and Kinks for the Amateur Radio. The amplifier is a single transistor powered by the 8 volts from the radio transceiver. I can't find any vintage desk microphone casing so I ended up with this pink jewelry box which I obtained from a novelty store, anyway the output audio was very nice and a little treblish. All the needed parts are available at my favorite electronic store at very minimal cost. ---73 de hevir

Posted by hevirred at 4:04 PM

2 comments:

Udo Visintini November 11, 2009 at 3:43 PM

Nice project ... 73 de Udo

Reply

jay s November 26, 2009 at 1:54 PM

Very nice and informative website...congrats. jay

Reply

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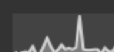

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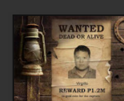

hevirred

Ham since 2000.

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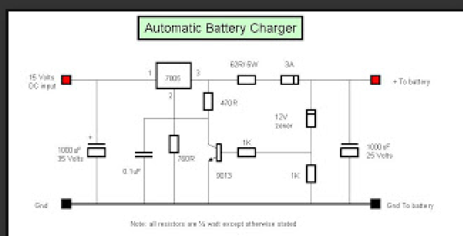
All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Friday, July 9, 2010

Automatic Battery Charger



Here is a simple battery charger circuit intended for 12 Volt gell-type battery. Current is limited by the 7805 regulator IC and the limiting resistor (62 ohms) to approximately 250 milliamperes, anyway most small sized gell-type battery capacities ranges from 2.5AH to 7.5AH so charging time should take several hours. When the battery is full, the regulator adjust its voltage output from 15 volts down to 5 volts automatically terminate the charging process. ---73 de hevir

Posted by hevirred at 1:15 AM

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  - ► November (1)
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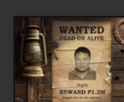

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Ham since 2000.

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KD1JV Digital SWR / Power Meter

This small, light weight digital SWR and power meter uses an Atmel AVR "Butterfly" demo board and a "Stockton" type directional coupler. It is built into a "Whitmans Sampler" candy tin. The display board is mounted to the lid of the tin, so the cover can be closed to protect the display when the unit is not in use or is in transport. This makes it an idea meter to use when traveling or in the field.

BNC connectors are mounted to the back of the tin, which support the lid when it is open. The directional coupler is made using a BN-43-202 binocular core, rather than two individual cores, which is normally done. Using the binocular core results in a lower profile and eliminates the need to cut slots in the board for round cores. W7EL diode compensation amps are used to linearize the output of the bridge diode detectors and results in much more accurate readings at low power levels than would be possible with out the compensation amp. A micro power CMOS rail to rail op amp is used. This allows the amplifier to run off the same 3 V button cell which powers the AVR board and draws so little current, there is no need to remove power from it when the unit is not is use.

The meter has two power ranges and calculates SWR. A 5 way "joystick" switch is used to control the AVR board. Pushing the switch "UP" turns the display on. Pushing the switch "IN" steps through the meter functions. 15 watt scale (00.00 watts) 9 watt scale (0.000 watts) and SWR (01.00) . There is an automatic 5 minute shut off (turns off the display and puts the processor to sleep). The control switch can also be pushed "down" to put the meter to sleep.

Accuracy: Just because the display has 10 and 1 mw resolution, doesn't mean you should believe it! There appears to be some what of a "bow" to the response curve, with readings which are as much as 200 or 300 mw high at mid scale. I believe this is caused by slight over compensation by the diode compensation amp. Even so, this only a few percent error, so no big deal. Also be aware that a meter of this type is only accurate when driven by a true sine wave. A distorted or asymmetrical signal will not measure properly.

Round off error: The A/D converter is a 10 bit, 1024 count converter. In order to measure up to 15 watts, we need to measure the equivilent of 40 volts. Therefore, the A/D count is multiplied by 4 to scale it. The over all scaling factor of the coupler is 40:1, so things work out properly. Because of the X4 scaling of the A/D count and the relatively small resolution of the A/D, the display will not count in single digit incerments all the way to full scale. At some point, the display will start to count in 2's and then 3's as the numbers get larger. (or 20's and 30's if on the 1 mw scale)

SWR calculations are pretty accurate, as this is simply the ratio of the forward and reverse voltages. The main thing which will affect the accuracy of the SWR calculation is how well matched the forward and reverse voltage detectors are matched.

The Atmel AVR Butterfly demo board is available from Digi-Key for $19.95 (part # ATAVRBFLY). In order to use the demo board for this project, you will have to reprogram it. In order to do this, you will need to down load AVR Studio 4 from the Atmel web site (http://www.atmel.com) This is a 20 meg file, so if your on dial up, it will take a good hour to down load. While your at the Atmel site, also get the Mega-169 data sheet and the Butterfly user guide. The user guide will show you how to reprogram the Butterfly board. Reprogramming is a simple matter of wiring a DB-9 serial connector to the Butterfly board and using the serial port of your PC. The processor on the demo board has a "boot loader" program which makes this possible.

Software:

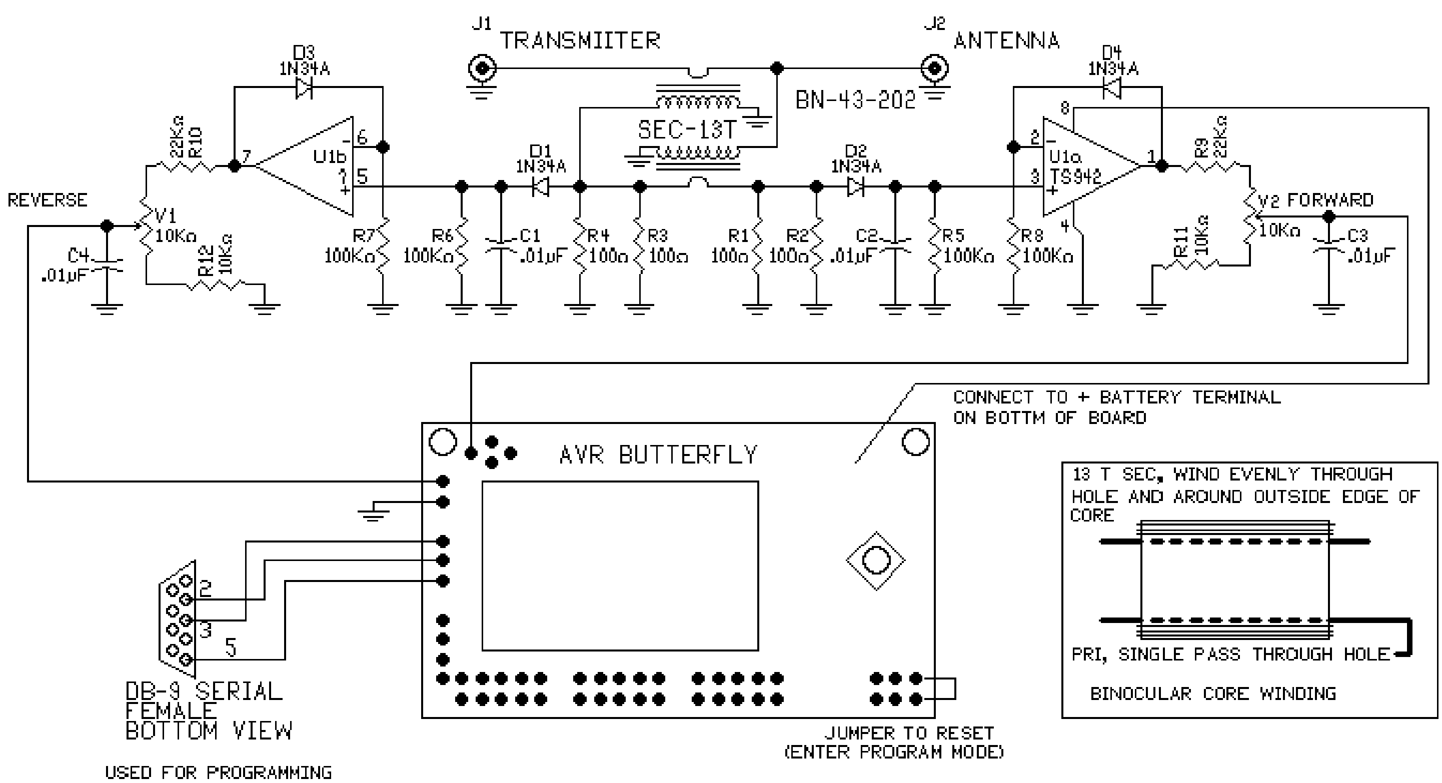
You will also need the power meter software which I wrote. Down load it here: Butterfly.zip

This zip file also contains a program to use the Butterfly board as a DDS controller for the AD9850 DDS daughter board by NJQRP. An html document explains this program.

Calibration:

Idealy, the meter would be calibrated by comparing it to a watt meter which is known to be accurate. Reasonably good calibration can be achived by applying a 2.21 DC voltage to the bridge side of the detector diode (D1 or D2), then setting the trimmer to display 10.00 watts. (actually, you can only get 10.01 or 9.98). If this method is used, be sure to disconnect the transformer first, or it will short out the DC supply.

Reverse power is not displayed, so to calibrate the reverse power side, move the forward power input lead to the Butterfly board to the reverse power output. If your using a watt meter for calibration, reverse the antenna and transmitter cables. Calibration of the reverse power detector is required to get accurate SWR measurements.



Construction:

I built the bridge and diode compensation amp with primarily SMT parts and etched a circuit board. If you have a pcb layout program and can make your own boards, this is the best way to go. You could use leaded, through hole parts if you wish and build it "dead bug" style. The circuit is simple enough, it won't take too long to do this. In some places, like mounting the leads from the balun transformer, you may want to cut "Islands" out of the copper foil to make connections. I prefer this method over "Manhattan" style construction, as I can never get the little pads to stick, hi.

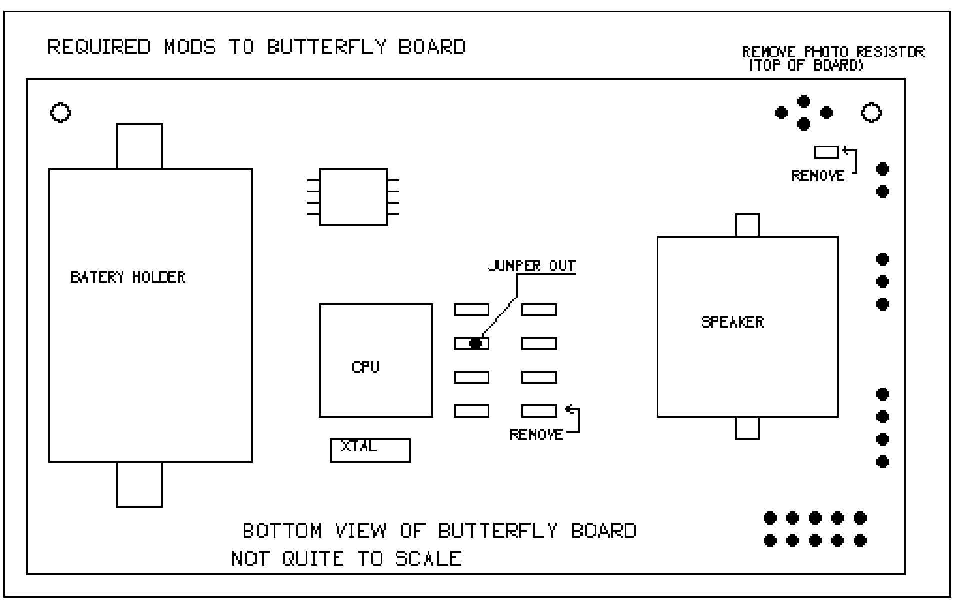
What might not be entirely clear from the diagram above is your making two transformers with one balun core. Therefore, there are two secondary windings, each wound through one hole and around the outside edge of the core. Use a small enough wire so most of the turns stay on opposite sides of the core. This will minimize any cross coupling between the windings. The primary is a simple wire which passes through the hole, one on each side.

The BN-43-202 core might be a little hard to find. W8DIZ of <http://www.kitsandparts.com> carries BN-43-302 cores which will work just as well (the '302 cores are a little shorter than the '202's) Diz is a good source for all your toriod needs.

The op amp used is a STmicrodevices TS942. It has a very low operating current of 1.2 uA per amplifier, so it won't drain the battery much! These are available from Mouser in both SMT and DIP. Germanium 1N34A diodes are shown used on the schematic. These can be a little hard to find. High speed Schottky diodes (not rectifiers) can be used instead. A type such as Digi-Key # SD103CDICT would do. Ideally, you should get enough of either diode to be able to match the forward drops between the diode used as the detector and it's corresponding compensation amp.

There are a few modifications required to the Butterfly board. These are shown below. The photocell resistor needs to be removed, along with two little resistors. A third needs to jumped over, which is a little easier than removing it and then jumpering the pads.

The exposed side of the battery holder is "hot", so putting some electrical tape behind the lid of the tin is a good idea, so when you mount the board, it doesn't short out.



HOME PAGE

APPENDIX

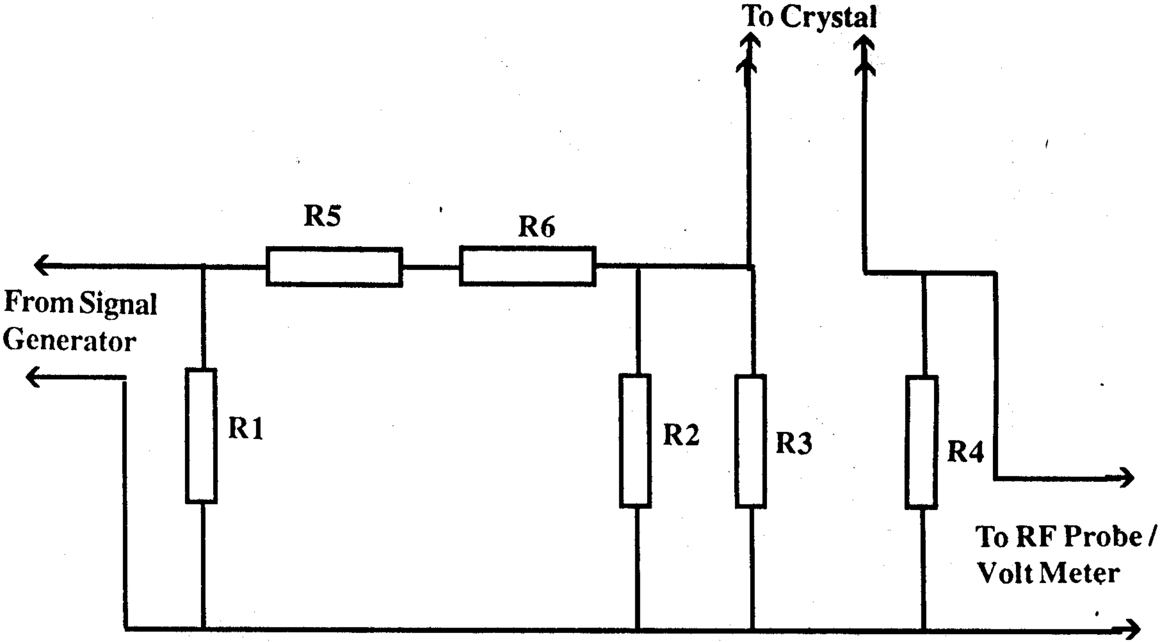
EQUIVALENT SERIES RESISTANCE TESTER

The crystals selected for signal filter must lie their frequencies within the tolerance of (50 HZ. (Actual frequency is not important.). The effective series resistance of every crystal must be very low. It is recommended not to use the crystal if its ESR is greater than 50 ohms. Lower the ESR, better will be the performance. If you purchase crystals in large quantities, you can group the crystals according to their frequency including tolerance and the ESR so that almost all can be usefull. For example, I have noticed that only one crystal was having very low (6 ohms) ESR. Almost all crystals showed ESR within 15 to 25 ohms. I was able to group the crystals according to their frequency and ESR, and obtained 6 groups to construct 6 SSB filters. The remaining crystals were still usable as carrier oscillators.

Test setup and testing.

The test circuit is shown in the figure . Test procedure is as follows:

Insert the crystal in the circuit and feed RF signal with the frequency near to the crystal frequency (printed on the body of crystal). Give sufficient RF voltage to get a deflection on



CIRCUIT DIAGRAM OF ESR TESTER

the RF meter or RF probe.

Vary the frequency of the signal source to peak the RF strength read on the meter. Note down the frequency and the peak reading. This is the center frequency of the crystal. Note down the frequency also .

Now replace the crystal with a carbon potmeter of say 500 ohms. With the wiper contact shorted to one end terminal of the potentiometer. Please do not disturb any other setup. Note down the RF meter reading. Adjust the potentiometer if there is any any change in reading compare to the previous reading. After setting the potentiometer, carefully remove the potmeter from circuit and measure the value of the resistance of potmeter with a good multimeter. This resistance is equal to the ESR of that crystal.

Repeat the steps 1,2, and 3 for all crystals you have and note down the readings. Compare the crystals with the readings thus obtained to group the crystals.

COMPONENT LIST FOR ESR TESTER

Resistors		
No.	Item ID.	Description
1.	R1	82 ohm 1/2 W
2.	R2	220 ohm 1/2 W
3.	R3	82 ohm 1/2 W
4.	R4	50 ohm 1/2 W
5.	R5	39 ohm 1/2 W
6.	R6	270 ohm 1/2 W

[DIY Audio Home](http://www.pmillett.com/)

7044 push-pull amp

OK, I admit I more-or-less stole this idea from Bob Danielak's 5687 amp...

Having a bunch of 7044 computer triodes laying around (a lot like a 5687, also 7119/E182CC), and a couple of Hammond 125J's I bough for the EL34 SRPP project, I thought I'd throw together something useful out of them.

Unlike Bob's amp, I used 6922's as drivers, in a configuration with a grounded cathode stage driving a split-load phase splitter, which drives the 7044's (two triodes paralleled). The gain worked out just right.

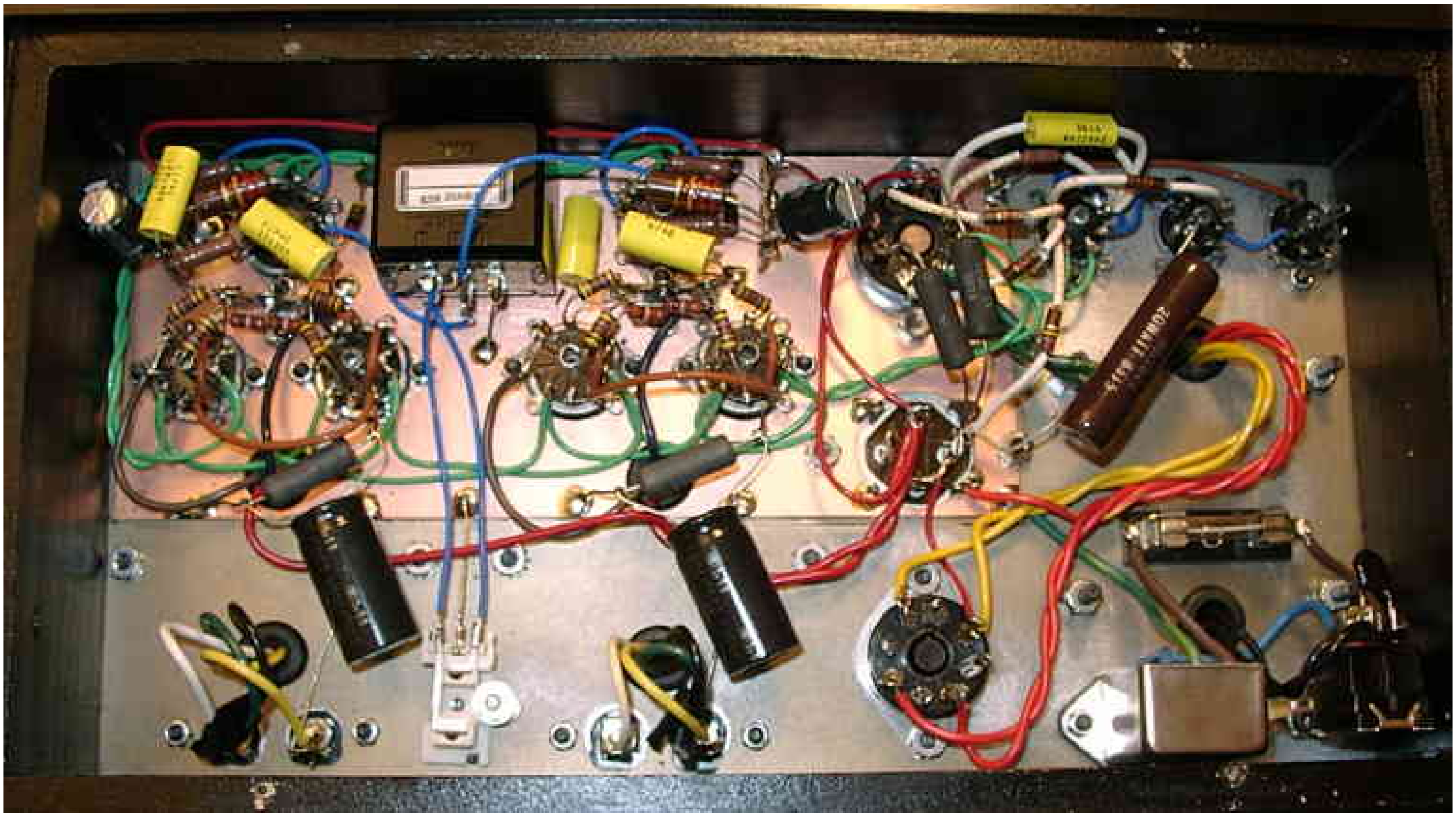
This amp has very low distortion... to a point. Mostly third harmonic, which isn't really ideal, but it is push-pull. I guess the single-ended driver contributes very little to the distortion.

With the Hammond 125J's I only get about 2-3 watts out of this puppy before the transformers start to distort. Seems like you should be able to get at least 5-6 watts with a better transformer. But I'm using it to drive some TQWP's with Fostex's in them, and 2W is more than enough.

The other unique (?) thing about this amp is the power supply. Since I have more tubes than sense, instead of bothering to go out and get a filter choke for the power supply, I just made a tube regulator instead. I also got by with very little capacitance, 40uF cap input filter plus another 20 on the regulator output, from a multi-section can I had laying around. The regulator is the "usual" circuit, using a 6AS7 or 5998 (the cool-looking pink base tube in front is a GE 5998A) pass tube, 6AU6 error amp, and an 0C2 and 0A2 for reference and screen grid. The 75V 0C2 really lights up bright!.

The amp sounds good, though almost a tad on the solid-state side! Maybe the 6922's.... I'm really a 6SN7 man myself.

Here's a picture of the inside of the amp. I used a small piece of PC board material to make a ground plane. This worked really nicely, and I could just solder down a terminal strip where I needed to, without drilling any holes.



The input tubes are at the top of this picture, on either side of the black volume control pot. The VR tubes are in the upper right, rectifier at the bottom, with the can cap above it and the pass tube above that.

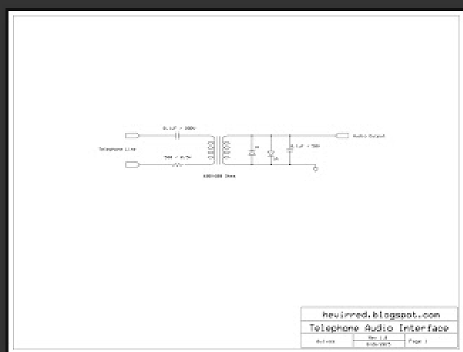
Here is the schematic (2 pages, 53kb PDF file)

du1vss home brews

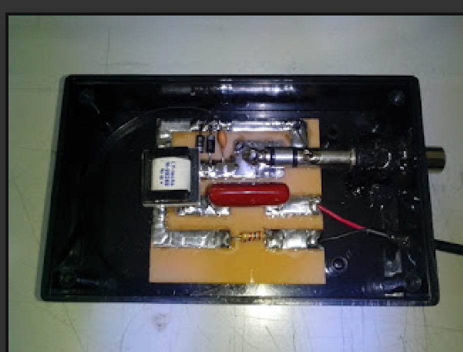
All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Wednesday, August 26, 2015

Telephone Audio Coupler



This circuit is a simple one, audio signal from the telephone line is sampled by the 600:600 ohm isolation transformer. The combination of 0.1uF/200V capacitor and 500 ohm resistor suppresses the high voltage present in the line during the ring signal.



Signals appearing at the secondary side of the transformer is clamped at 1V peak to peak by the two diodes connected back to back. Audio level at this point can be easily processed by an audio mixer before going to the transmitter. ---73 de du1vss.

Posted by hevirred at 2:02 AM

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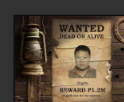

hevirred

Ham since 2000.

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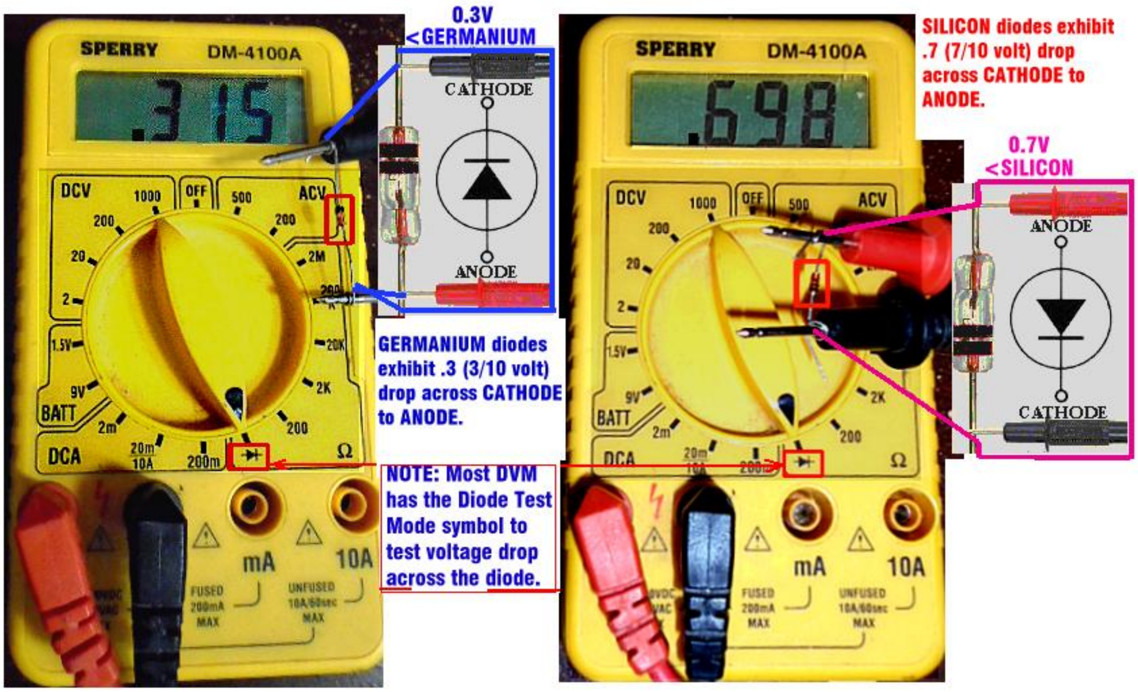
Germanium vs Silicon Diode Testing: Read this document carefully, so you will not be the victim of cheap knock-off or the wrong type diodes.

The general rule is that ***SILICON*** diodes have a voltage drop across the Anode to Cathode of 0.7 V (7/10 tenths), and the ***GERMANIUM*** diodes have a voltage drop of 0.3 V (3/10 tenths) more or less. Either diode voltage drop (silicon or germanium) will display a reading within approximately 5% of these readings.



Most digital meters (DVM) have a switch setting that is used to measure voltage drop across these diodes. This setting is usually indicated by a diode symbol to let the user know the DVM is capable of measuring forward bias voltage. This setting will tell you immediately if the diode is a **germanium**, or **silicon** diode. You need to set the selector switch on your meter to the diode test symbol .

Measuring Forward Bias Voltage

To measure the forward bias voltage characteristic you connect the black probe of your meter to the cathode terminal. The cathode terminal is on the end with a band. You then connect the red probe to the anode terminal.

Set your DVM/DMM to the *diode test mode* , it should provide you with the respective voltage drop. If the figure is 0.3 V or less, the diode is a *germanium* type. If the voltage drop is 0.7 V or less the diode is a *silicon* diode.

Sensitivity and Forward Bias Characteristics:

The sensitivity of a diode to radio waves depends upon its *forward bias voltage*. This is the voltage across the diode terminals. When it falls below this threshold value, the diode will stop conducting. Obviously, the lower this threshold value is, the greater the sensitivity of the diode to the weak radio signals.

CONCLUSIONS:

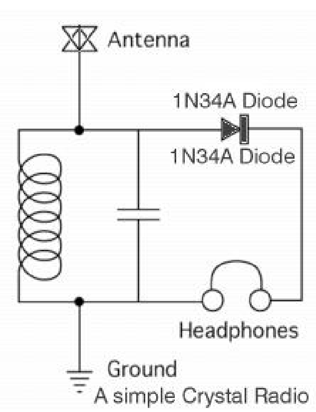
When comparing germanium diodes with silicon diodes of similar forward bias voltage, silicon diodes do not perform as well as the germanium.

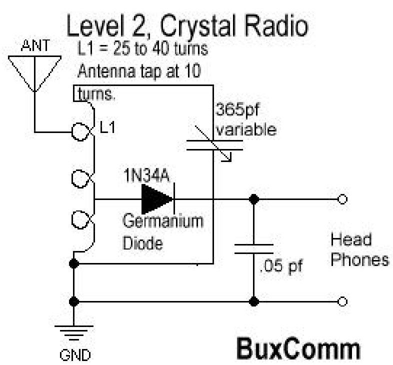
Germanium has many properties that silicon diodes do not have. Germanium requires very little forward current. Forward current in a germanium diode is in the *micro*ampere region, while silicon diodes require *amperes*. This makes *germanium* a much better choice for both medium and high frequency radio signals.

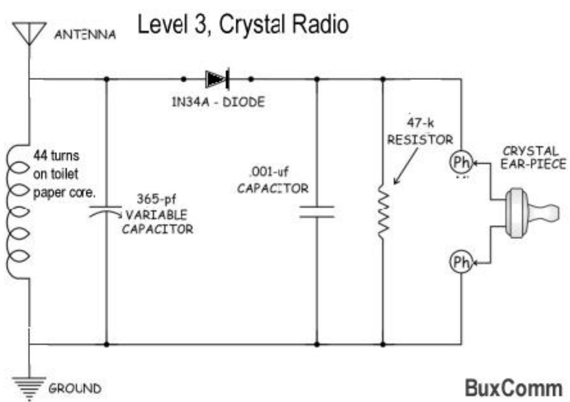
Germanium also exhibits a very low, point-contact junction capacitance, while the silicon diode has much higher capacitance. A low junction capacitance allows germanium diodes to operate more effectively at high RF frequencies.

In addition, reverse leakage current for germanium diodes is in the magnitude of 1000, much more than silicon. This makes the non-linear characteristics of the germanium diode much more effective for RF detection and demodulation than silicon.

Therefore, our conclusions are; germanium diodes provide the best performance in crystal radios, RF probes, HF, and VHF signal detection.







BuxComm High Quality, CRYSTAL RADIO ANTENNA KIT, $14.95 cat# 50CRAK

This Crystal Radio Antenna kit consists of 50 feet of #16 AWG insulated & stranded copper antenna wire, two heavy-duty, Delrin, UV resistant antenna insulators and instruction sheet.

GO KIT:
DAILY EMERGENCY COMMUNICATIONS GEAR IDEAS

Nov. 21st, 2001, By Steve KB1DIG & Kim KB1GTR

How do we get all this HT equipment out of the drawer and into our hands when we need it? With a little research, we came up with the ideas and links posted in this section.

Our favorite *quote* comes from C. Edward Harris, KE4SKY, VA RACES State Training Officer: *"It is better to have the bare essentials always handy than to leave a bulky pack someplace where you can't get to it."* This has been our inspiration for this project. As always, we are open to your suggestions and comments.

A PLACE TO START:

If you find the perfect guide to how to make an emergency kit, please let us know. Suggested lists and opinions we've seen vary from one big kit to several different size kits. The purpose of the page is to focus on something that will work for everyday use. A small bag to place on the front seat of the car, on the way to work. Something more practical, packed with the basic items that we believe will help if we find ourselves participating in an emergency.

THE BASIC LIST:

This is the primary list for our kits. It works well with what we have available to us today. **Items in red** are optional and not always packed. Flexibility is dependent on daily activity. An example would be if we were planning a weekend away from home, to a Hamfest. In this case, we will pack up the chargers and leave out the candy and snacks.

Radio Equipment Items:

Triple-band HT
Operating Manual (supplied with HT)
2m / 70cm antenna (supplied with HT)
Antenna "Extender Element" for 6m use (supplied with HT)
High gain dual band antenna for 2m / 70cm use.
Extra high-capacity battery pack.
Battery charger (supplied with HT)
Rapid charger attachment to Battery charger
Cigarette lighter cord

Two extra 3A fuses, for Cigarette lighter cord
Speaker / microphone
Male-BNC-to-SMA adapter
Female BNC to SO-239 adapter

Other Items:
Copy of FCC Operating License.
Mini-Mag-Lite, extra bulb and spare AAs
Leatherman multi-purpose tool
* (2) Ink pens
* (2) Pencils
Paper notepad (self-stick removable notes: 2 7/8" x 4 7/8" size)
Swiss Army pocket knife
Emergency gas / phone money ($10 bill, + four quarters and five dimes)
Hard candy
Granola bars
Band aids
Surgical gloves
Disposable lighter

* Note:
Pencils for writing. Pens often fail, freeze in the cold, and they smear in rain. It's good to have an extra Pen around if you're at the Bank and need to cash a check. Other then that, stick to using a Pencil. They can be sharpened with a pocket knife and cost almost nothing to replace.

MORE MISCELLANEOUS STUFF:

This is a list of additional things that we are still in the process of rounding up. A few other ideas. Not all are necessary. Remember to think small...

Planned Items:
Small pocket compass
Local ARES phone and frequency reference card
Current eye glasses prescription.
Moist towelettes.
Operating quick reference card for HT
Pocket sewing kit
Sunscreen (small size bottle)
Aspirin
Tylenol
Antacid tablets
Throat lozenges
Role of electrical tape
Ear phones
Cable ties
Whistle
ALL Family Members emergency contact list
State road map

HOW TO PACKAGE:

Believe it or not, this was the hardest piece of the puzzle to find. We looked around several department stores and always found ourselves in the camera section. We felt the best choice was some type of padded bag with straps and divider sections. The camera bag seemed to suit the bill, but the prices were not cheap. As an alternative, Kim came up with a good solution. She discovered that a soft type lunch box will work. They were padded and came in several different colors, shapes, and sizes. The inside seemed better suited for the items we wished to pack. The selection of colors was appreciated, as to avoid mistaking his from hers. Camera bags come mostly in black. Best of all, the price was right!

SPECIAL PROJECTS:

Some food for thought... Nothing is cast in stone. It's okay to personalize. Here are few items that didn't make it to the list sections above. Some of these items and ideas are from our next big project. The 72hr Emergency Kit. Remember to use your own ideas, also.

Place the photocopy of your Amateur License in laminate. This way it will last for years. 3M™ makes several different sized self-laminating card protectors. Easy to use...no special tools or equipment needed. We took this one step further and chose the Luggage Tag style. The plastic was a little thicker and it has this neat little slit molded into it. A great place to attach and use with your ARRL Amateur Radio ID Badge Lanyard.

LABEL YOUR EQUIPMENT! This isn't your Mom... If you are rushing around, it's easy to forget something. People are basically honest and will make an attempt at returning lost items. Fellow Hams, even more so. Especially if you were trying to help then in an emergency. What we do is make up stickers with just our Call Letters. We have an Electronic Label Maker that we purchased form Staples. You do not need to be so elaborate. Home address ladels will do the same thing. The point is, without a form of identfication you equipment will stay lost. Mom was right...

We pack a green and orange highlighter for marking on a photocopy of a street map. This was a necessity in New York City. It was a running joke at TSA Headquarters. We had the only green highlighter and needed a sign-up sheet to use it. We will probably never use them much. It just feels good to know it came in handy. You never know… Kind of our safety blanket, we suppose.

Steve packs an American Flag. It's the little one that hung from our pickup truck antenna during our NYC/WTC trip. The stories it could tell. Another one of those good luck charms.

Don't forget about that void under your drivers seat. This is another place to stash stuff. A collinear design roll-up 2-meter J-pole is in each of our vehicles. Too big to pack, but always handy. This is a good place for that extra quart of oil, the jumper cables, some good leather work gloves, and the campers rainwear.

Take a look at some of those new technology LED flashlights. Energizer makes a new folding lantern version with a lifetime warranty. It has 2 LEDs and runs on 4 AAs. What's neat is that the LEDs never need replacement. Also, the thing will continues run 200hrs on 1 bulb or 100hrs on 2 bulbs. The only bad thing is the size is a little less than a pack of cigarettes. Looks like a Star Trek Communicator. Not that big, but big enough…

Some packing tips. Some items do not travel well. How to avoid the damage? We use some of that smaller size bubble

wrap, plastic bags, and elastic bands. Not rocket science, perhaps. This bubble wrap stuff is available at several department stores. It comes in sheets at about a quarter of an inch thickness and can be cut to any size or shape.

THE BOX: PORTABLE EMERGENCY COMMUNICATIONS STATION IDEAS

Have a suggestion?

David WB2AZE: Hi Steve, saw what you had on the website. It looks very good and I would like to add my 2cents.

1. I use a larger plastic toolbox for my go kit. I can carry a spare HT, 7ah gell cell, d cell alkaline battery holder, spare antennas, connectors, lantern, etc in it and don't have to worry about the handle breaking from the weight of the batteries.

2. Insect repellents West Nile and Lyme Disease is up in the East Coast. I find that Avon Skin-so-Soft has a sunscreen and insect repellent combined.

73's
=====
WB2AZE David R. Kanitra
Level EC-001
ARRL ARES District Emergency Coordinator for
Hunterdon County, NJ
http://groups.yahoo.com/group/HunterdonARES

Steve KB1DIG replies: ...Great Go-Kit ideas!! We just started moving towards large Rubbermaid plastic totes with wheels at this QTH. Short $$ at Wal-Mart. Too much stuff to bring now as the new local EC... Kind of the same idea as the tookbox.. Hope this helps keep larger items weather protected in the back of the pickup now.... Thank you! 73..

China Markers: In addition to pencils, I also have black and red china markers. I have written more than one message on a window and on the side of a car or van. They are waterproof and work great. You can use them on a small “dry marker” board for writing outside in a complete downpour.

Generally any crayon will work very well.

Charles Crizer, KF4MNE
Disaster Services - Communications
American Red Cross of the National Capital Area
202-359-9581
kf4mne@arrl.net

American Red Cross

Rite-in-the-Rain Paper: I'm a geologist and have used this product for many years. You can literally write on it w/a pencil during a downpour. It also comes in standard 8-1/2x11 inch pads and I often photocopy field maps on it. The paper is great. It blows people away to see water sheeting off the page in a downpour and I'm happily mapping!

Best "r-i-t-r" notebooks are in bound format ($15 to 17). Covers for spiral bound and stapled ones fatigue very quickly w/regular use in wet weather. Box of full sized 8.5x11 sheets for copiers is $24 for 200 Sheets (use conventional toner copiers, not ink jets for obvious reasons!)

For fair prices, quick service:

http://www.forestry-suppliers.com

http://www.benmeadows.com

Get a catalog. It's like a big candy store! Hard hats, safety vests, boots, compasses, FRS radios, GPS, foul weather gear......

And the Source itself:

http://www.riteintherain.com

Forestry Suppliers also sell aluminum enclosed clip boards that are nearly indestructible. They have a 5x7 format that fits well inside a jacket for $18.

Jim Falls, KG6FWT
President, Humboldt Amateur Radio Club, Eureka CA

Dont forget your handy dandy ladderline jpole or even dipoles... great range extenders and with 50 feet of light cord you can be 20 feet in the air in a few seconds... I use a fanny pack with about 25 feet of coax and 50 feet of cord. I use a two pocket pack ... small pouch fits misc rf connectors and compass etc... turns a HT into a great emergency station just about anywhere you can throw a line!

73 de
Randy Atkinson
kc0iqm

Dave WB1COB: First of all, excellent article. Please check out our club website at www.cqradioclub.org , we are interested in similar projects,

1) Space Pens: FISHER and EVERSHARP make refills that come with an adapter so the refill can be used in a Parker, Diplomat, or Pelikan pen. So instead of a $30 Space Pen which is the same as the one that went to the moon, I use a "give-away" pen which had a Parker refill. If it gets lost I am only out the cost of the Space Pen refill. After all the pen itself doesn't do the writing, its done by the refill. My pen didn't go to the moon, but it still writes upside-down.

2) HT Batteries: I have alkaline battery cases (even extras) for each HT. I bought these when the HT's were brand new with the intention of never buying the $100 special super-duper battery pack. AA cells work just fine. Maybe I get 4 point something watts out instead of the full 5 but I'll deal with it. Talking into a rubber duck to a repeater, it doesn't matter anyhow.

I also started using rechargeable alkalines. The chargers packed with the HT each handle 4 batteries, that gives me two extra for the mini-mag lite. The AA cells also work good in LED lights, broadcast radios, weather radios, etc.. Love those AA cells.

The flat AA cells can also be put aside and replaced with onetime use batteries if you need them in a hurry to stay on the air. I would not purchase an HT unless I can get an alkaline battery case for it.

3) Leatherman: Use them, love them, but I have a good quality $5 one from Ocean State Job Lot in my kits. It's a little bigger and made in China (phooey), but it works well. There are also many poor copies out there (real phooey).

4) Compass: One item I will not settle for anything less on is a SILVA compass. They come in various price ranges, and are very well made.

5) LED AA Flashlight has no bulbs to worry about replacing. We use a $15 from Wal-Mart lithesome different color lenses. Mini-mags are OK, cost $9 and do at least have a spare bulb.

Those folding Eveready LED lights make a good desk light when you unfold just right. Have you done that yet ? I used mine during an ice storm we had in November like that.

73
Dave, WB1COB
CT ARES DEC Hospitals
CQ Radio Club Webpage: http://www.cqradioclub.org

Steve KB1DIG replies: ....I have not used the folding Eveready LED light that much. A few times.. It is cool though. Great idea as a desk light. This one I have is in the Go-Kit all the time. Will keep it in mind.

The LED light I do seem to use all the time now is made by CMG Equipment. It's very small and uses a single AA-cell battery and has a good sized single LED. It's mostly sold for under $20 and also used by the US Military. With one AA it burns for perhaps 24 hours or more. I clip this to a baseball cap. Looks a little strange but works great. Good for under the hood of the car at night, in the rain. I keep it on my key ring along with a mini multi-pliers tool made for Sears, by SerberTech. Can't beat that Craftsmen Lifetime Warranty!

I use all this stuff in place of the good old swiss-pocketknife that's now with the Go-Kit. I keep the pocketknife on another key ring, together with the mini mag-lite attached as a backup. It's on an outside pouch, so I can get at it easier. That's the plan...Works for me..

Web info links:
CMG Equipment:
http://www.cmgequipment.com/Infinity_New.html
http://www.equipped.org/led_lights1.htm#cmg

Small multi-pliers tool: (also called the M4 SeberTool)
http://shop.store.yahoo.com/squaredrive/stm-0004.html
http://www.argussupply.com/images/sr-2000c.jpg
http://www.agrussell.com/seber/

Thank you Dave!!

You may as well have the latest versions of my articles:

I was visiting your web site. You have done a nice job and your page will be a valuable resource. I see that you have an older version of my article on "Go Kits".

I have attached the latest Word version, as well as some other materials in .pdf which may be helpful. These may be posted on your web site for noncommercial, nonprofit, educational and public safety use within the scope of the U.S. Copyright Law, as long as they are presented complete and intact with source credit to Virginia RACES, Inc. the owner of this work.

In the next few weeks the training page of the Virginia RACES web site www.varaces.org will be completely revised with new and updated material. Stay tuned.

Charles E. Harris, KE4SKY
Emergency Response Planning Coordinator,
Virginia RACES State Training Officer
Fairfax County Department of Public Works and Environmental Services
Division of Solid Waste Collection and Recycling
12000 Government Center Parkway, Suite 466
Fairfax, VA 22035-0060
Telephone (703) 324-5224, Fax (703) 324-3949

e-page 7037025856@page.metrocall.com

This is a shortcut to training page for Virginia RACES:

http://www.va-ares.org/html/va_races_training___reference.html

FREE DOWNLOADS:

TECHNICAL & REFERENCE MATERIALS

TRAINING MODULES & EMERGENCY COMMUNICATIONS COURSE MATERIALS

"Virginia RACES Training Materials Are In Use By Well Over 500 Organizations In The U.S. and Around The World. Our Terrorism Module Has Been Downloaded Over 29,400 Times. Unfortunately, We Cannot Honor Requests For CD's Due To The Sheer Number Requested And The Cost And Time Involved."

This information is under constant revision and update.
Ed, KE4SKY and the Virginia RACES, Inc.Team
Thank you all very much for providing us with the use of this information!

"Somethings to consider, roadside flares, reflective safety vest, rain gear, good boots, insect repellent."

"I forgot to mention carrying a pre-paid phone card."

73 de Keith

KC8TCQ
American Red Cross - Disaster Services
Board Member - Henry County Chapter American Red Cross
Health and Safety Services Instructor - Henry County Chapter American Red Cross
Vice President: REACT of Henry County

Speaking of the space pens and getting your paper wet, try http://www.riteintherain.com
They offer all kinds of waterproof notepads and items for field use in any weather. For $10 you can order their sample pack which includes 2 notebooks and a space pen plus other samples.

I used them, and I'm about to order more. Definitely a site to check out.

73
Joe, N2ECR

Lee suggests: "One thing that I would add to my emergency kit would be a self heating MRE. For the money vs. shelf life they are not that expensive." Thanks Lee!

Lighters and Matches: Great topic. Several postings. Thanks to all for your contributions!

A Radio Worth Buying

RadioShack's Model #12-803 AM/FM/WX/SW Self-Powered Portable Radio
Owner's Manual in .pdf format

Lee suggests: "Get a copy of the C. Crain catalog, in it there is a light that will last the better part of forever. Also there is all kinds of stuff that hams like." Thanks Lee!

Greetings:

Nice job on your kit. I would add a personal water purifier. REI sporting goods has several. Most MRE's require water. Your body requires water. Space pens are more expensive but work in extreme environments. Surgical gloves and Band aids I would recommend to be carried at all times. Pen light location is GREAT! A reflective cloth strip added to the outside of the kit identifies it as yours and easier to find in the dark.

Dan W. KG6JCH

Your members should consider Coast Guard Approved water pouches and survival food bars. They are very compact, temperature tolerant, and less likely to incur damage than bottled water. The food bar takes much less room than even one MRE, which one of the notes suggested. However, the MRE provides ONE meal, and the food bar provides NINE meals. Also, if someone is using a currently manufactured MRE, it should NOT require water, except for the beverage mix. It is a misconception that water is needed to hydrate the food. If someone has a pack that has food that needs re-hydration, it is most likely an older, surplus unit, with unknown remaining shelf life.

Both the CGA water and food have a five year shelf life, even in the heat of a car in a hot climate. On the low side they tolerate down to (?) below zero..... I seem to remember 40 below, but don't quote me on that. I can check to see exactly if there is interest. The water pouches can slip into a pocket, under a cap, under the car seat or console, etc. very easily. If people are carrying bottled water, it is
subject to much more damage from weather or disaster conditions, but it can also spill or become contaminated once opened. The CGA water pouches are in 4.225 oz. individual portions, which is just right for either a drink or washing your hands, while the unused portion of your supply of pouches stays perfectly sealed and pure.

Also, on water filtration units, it didn't used to be a problem more than removing living organisms. The thought was that a few chemicals in water for a temporary period like a disaster would not justify adding chemical purification elements. Now that is not the case, since we have more potential for chemical toxicities to occur. Therefore, we now provide the Katadyn combi, rather than the Katadyn pocket, so that the filter addresses both potential problems.

Please inform your members that filtration is now about the best option for purification and that all traditional purifying items like bleach, iodine, potable aqua, etc. are no longer completely effective even for biological organisms and there are new complications in their use.

If you have any questions, please let me know. I have quite an extensive background in these things.

April Kelcy, Consultant/Educator
Earthquake SOLUTIONS
(626) 795-4000
earthquakesolutions@earthlink.net
Pasadena, CA

Please send us your ideas and comments.

Send E-mail to: buck0@comcast.net Good luck building! Kim KB1GTR & Steve KB1DIG

SOME OF OUR FAVORITE EMERGENCY KIT INFO LINKS!

"What's In Your 'Go' Kit?".doc

Emergency Gear

Disaster Supplies Kit

Alpha Disaster Contingencies

EQUIPPED TO SURVIVE - Outdoors Gear, Survival Equipment Review & Survival Information

HAMS FOR ENDURING FREEDOM

PLEASE CHECK OUT OUR HOME PAGE!

Steve's and Kim's First Home Page!

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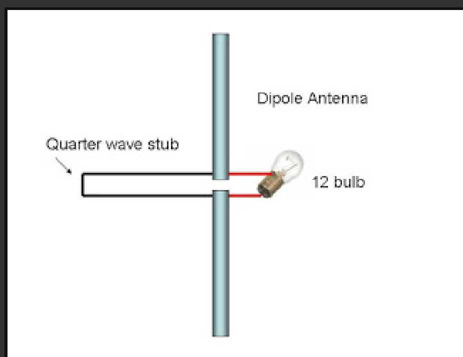
du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Friday, September 4, 2015

Quarter Wave Stub Demo



One of the trick that you can perform to your friend (not a Ham) is this quarter wave stub. Looking at the DC (direct current) point of view, the bulb should not light since there is a shorting wire (stub) that will ground any voltage present across the 12V bulb. But strange things happen when a strong rf source is brought near the dipole antenna. The bulb should light brightly! This phenomenon can be easily explained when we understand how the quarter wave stub behaves when excited at its resonant frequency.

In my prototype, I use a 435MHz 3w transceiver to excite the dipole antenna and the 12V pilot bulb was used as an indicator for rf current present across the feed point of the antenna. The antenna itself is approximately 13 inches in total length while the stub length is 6.5 inches. Spacing of the stub was merely approximated to around 1/16 of an inch. Part of the trick is that you can also cut open the far end of the stub and show to your friend how the bulb immediately off at this time. ---73 de du1vss

Posted by hevirred at 3:22 AM

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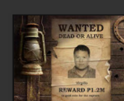

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AM LOOP ANTENNAS

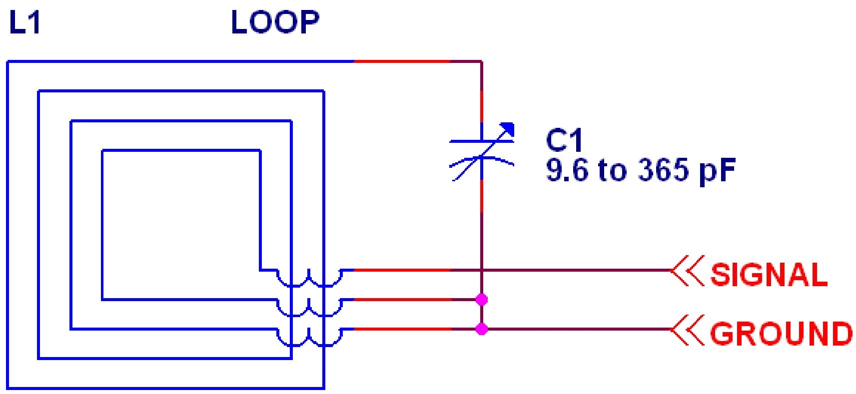
Now QUINN approved!

Erin Sanders, who plays the part of teenage inventor Quinn on Nickelodeon's "Zoey 101" show, with the author. She and her mother recently visited, and were impressed when this loop's little brother (also described below) was able to vastly improve very weak reception on KLBJ Austin (230 miles away) on an average radio. Used with a good radio, this loop is able to receive WWL 870 New Orleans, at almost 700 miles away (thanks to KJIM 870 Ft. Worth powering down).

Introduction

An AM loop antenna is one of the true marvels of electronics. Requiring no power, it takes advantage of the resonant properties of an inductor and a capacitor connected in parallel to receive weak AM stations. The "loop" part of the antenna is the inductor, and the tuning capacitor makes it resonate at a desired frequency. As a boy in Abilene in 1967, I discovered the basic principle of the loop antenna. By removing a relatively small spiral loop in my five tube table radio, and substituting a much larger loop salvaged from an older radio, I could receive my favorite station - KLIF from Dallas better. I hid the loop in a cardboard holder featuring the logo of a favorite rock band, and enjoyed many hours of good listening. Lacking the mathematical background to understand antenna theory - I could not take the concept to the next phase: designing my own loop. Nevertheless, the spiral loop - combined with the antenna section of the radio's tuning capacitor - formed a very good loop antenna. I understood quite well that the bigger the loop, the more stations I could receive.

The schematic diagram of an AM loop antenna is shown below. It consists of an inductive winding, which is supported on a frame, and a variable tuning capacitor that can be salvaged from a junk radio. The inductive winding consists of a primary, which forms a resonant network with the tuning capacitor, and a secondary "sense" winding that can be connected to a radio. In practice, however, the sense winding is not needed if the loop antenna can be placed near the radio - mutual coupling will take place with the antenna in the radio.



As nice as loop antennas are, there are some limitations you might want to consider before considering one:

- Large loops may be quite large and cumbersome. Even 8 inch loop antennas, however, may have high gain. Radio Shack and Terk manufacture very similar products - an 8 inch circular loop with a tuning capacitor embedded in the base. These small loop antennas can turn radios with poor sensitivities into modest DX rigs. Just don't expect a 6 transistor pocket radio to provide excellent reception if the distant station is near strong local stations - the selectivity and automatic volume control of the inexpensive receiver may not be up to the task.
- Loop antennas can be a bit difficult to use. If the target station is audible at all on the radio - it is a simple matter to put an external loop antenna nearby, and tune it until the weak station becomes strong. If the distant station is not audible at all, it may take several tries to "get it right". I discuss my remote reception site at length in the four foot loop article - so I won't go into detail here. I will mention briefly, however, that the radio in my daughter's room at "grandad's" is a 25 year old Radio Shack table model. There is no signal audible at all on my daughter's favorite station, which meant I had to tune the radio to a station nearby

- then tune the loop, then edge up the frequency on the radio, then the loop - etc. until the station comes in. The 8 inch Radio Shack loop brings it in almost without static! Once the radio was set, all I have to do is leave it from one visit to another. When I arrive, I put the loop near the radio, turn the radio on, tune the loop - done. Not too bad. Now if somebody ever touches the tuning on that radio between visits - it will be a bit of a hassle!

Why Another Loop Antenna Page?

Many articles have been written describing the construction of loop antennas, but they have been deficient in many respects. Some areas that are never adequately explained are:

- The differences between spiral winding and edge winding – which is better and why. I have elected to construct edge wound loops – it makes calculations easier.
- Whether the winding is spiral or edge, what is the spacing between the turns of the winding?
- Does the winding really relate to a standard tuning capacitor with a value of 9.6 to 365 pF, or does it use another value? My construction articles will specify the value of capacitance.
- Does the loop handle frequencies in the expanded band from 1610 to 1700 kHz?
- How is the loop interfaced to a receiver – where and how do you place the secondary? How many turns should the secondary be?

This introductory article will describe the mathematics of AM Loop Antennas and serve as the link point for construction articles. I have actually constructed several loop projects, and conducted controlled test of them from a remote test site. Construction projects are linked below.

Mathematics of Rectangular Loop Antennas

A loop antenna resonates according to the formula:

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

where:

- $\mathbf{f_O}$ is the resonant frequency in Hz
- **L** is the inductance of the loop in Henries
- **C** is the capacitance of the loop in Farads

The problem for loop designers comes in designing a loop with the desired value of inductance for their tuning capacitor. Ideally, the fully meshed position of the tuning capacitor should tune the loop antenna just below the lowest frequency in the desired band, and the fully open position of the tuning capacitor should tune the loop antenna just above the highest frequency in the desired band. In practice, this is sometimes a challenge because the AM band tunes over a frequency range that is 3:1 (1700 / 540 = 3.15). Surprisingly, I get the best results by adding more turns to the loop so I can use the newer 9.6 to 250 pf tuning capacitors. But then - there was a reason why transistor radio manufacturers did this in the first place - could it possibly be that it was easier to design antenna sections that tracked the entire band?

There are two formulas for loop inductance that I have found on the web - the Joe Carr formula and the UMR-EMC lab (University of Missouri-Rolla Electromagnetic Compatibility Laboratory) formula. I have used both in building loop antennas, and find the UMR-EMC lab formula works a little better. Both formulas are large, both are ugly. But this is the nature of loop antennas.

Incidentally, the "holy grail" of loop antenna design would be a formula that gives the dimensions of the frame based on the frequency, number of turns, and spacing of turns. I spent many hours working to derive such a formula from both the Joe Carr and UNC-EMC lab formulas. My attempts at derivation failed. The best thing for you to do is to tweak the dimensions of your loop to get the inductance - and therefore the frequency range - where you want it.

The Joe Carr Formula

The Joe Carr's Tech Note formula has worked for large square box loop antennas with wide spacing between the windings. It does not work for ribbon cable loops. It approximates rectangular loops provided that the aspect ratio is not too large. The formula is:

$$L(\mu H) = 0.008 \times N^2 \times A \times \left[\ln\left(\frac{1.4142 \times A \times N}{(N+1) \times B}\right) + 0.37942 + \left(\frac{0.333 \times (N+1) \times B}{A \times N}\right)\right]$$

Where:

- **L** is the loop inductance in mH
- **A** is the length of one side of the loop in cm
- **B** is the loop depth (thickness) in cm
- **N** is the number of turns

I have taken the Joe Carr formula and created a Javascript calculator for square loop antennas.

The UMR-EMC Lab Formula

The UMR EMC Lab formula appears to be a more general form of the Joe Carr formula. If I get some spare time, I may try to put h = w in the UMR EMC lab formula and see if it reduces to the Joe Carr formula. Anybody who wants to do this - write me and tell me if you succeed. The UMC EMC lab formula is:

$$L = N^2 \frac{\mu_0 \mu_r}{\pi}\left[-2(w+h)+2\sqrt{h^2+w^2} - h \times \ln\left(\frac{h+\sqrt{h^2+w^2}}{w}\right) - w \times \ln\left(\frac{w+\sqrt{h^2+w^2}}{h}\right) + h \times \ln\left(\frac{2h}{a}\right) + w \times \ln\left(\frac{2w}{a}\right)\right]$$

Where:

- **L** is the loop inductance in H
- **N** is the number of turns
- **w** is the loop length in cm
- **h** is the loop height in cm
- **a** is the radius of the spacing between wires (equal to the wire radius for adjacent winding, equal to 0.0635 for 0.127 (.050 inch) spaced ribbon cable, etc.
- $\mathbf{m_r}$ is the relative permeability of the medium - just use 1
- $\mathbf{m_o}$ is a physical constant - the permability of a vaccuum: m_o = 4p*10^{-7} T^2m^3/J = 12.566370614*10^{-7}

I also created a Javascript Calculator for the UMR EMC lab formula.

The Bob's Tesla Web Lab Formula

Many web articles utilize the Bob's Tesla Web Lab formula for loop antenna design. This formula is for a round loop, not rectangular, so I really won't go into detail here. It seems to work properly - when I reverse engineered the Terk AM Advantage - which is a circular loop:

- Radius = 4.234 inches
- Coil length B = 1.26 inches
- L = 318 mH

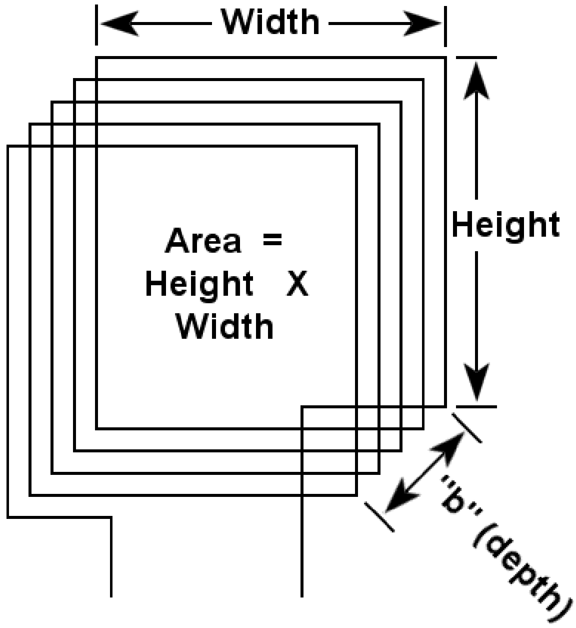
L calculates to 318 mH, which makes about 474 kHz with a 250 pF capacitor. A little low, but we know the Terk works, so probably adding in interwinding capacitance makes it correct. When I try to use the equivalent area for a rectangular loop, it doesn't work. I used the 3 foot loop as an example, the equivalent area circle has a 20.3 inch radius and coil length of 0.4. L calculates to 141 mH, which gives 700 kHz with a 365 pF capacitor, not even close! The 3 foot loops tunes to 540 with no problem.

Loop Antenna Mechanical Construction

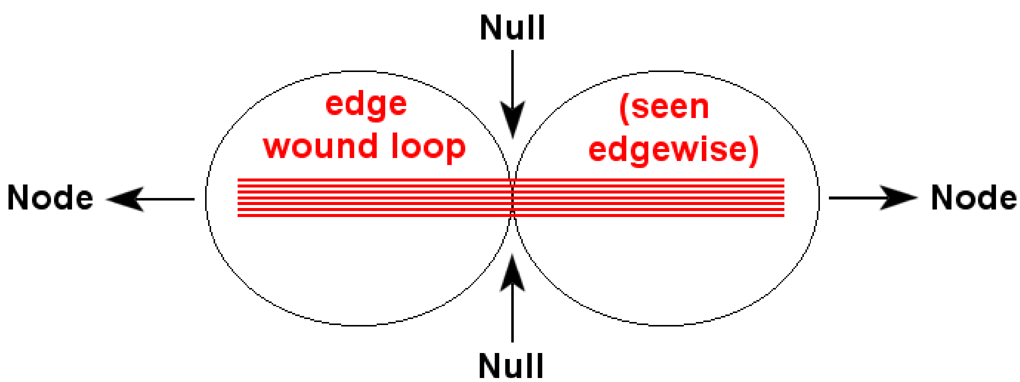
There are two choices for loop mechanical construction - edge wound and spiral wound. My construction articles are all for edge wound antennas, but many articles linked below describe spiral wound loops.

Edge Wound

An edge wound loop has each turn exactly the same size and on top of the preceding turn:



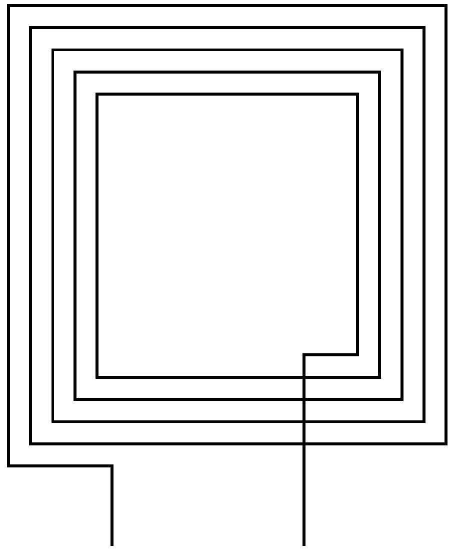
It is most sensitive to signals coming in the plane of the windings:



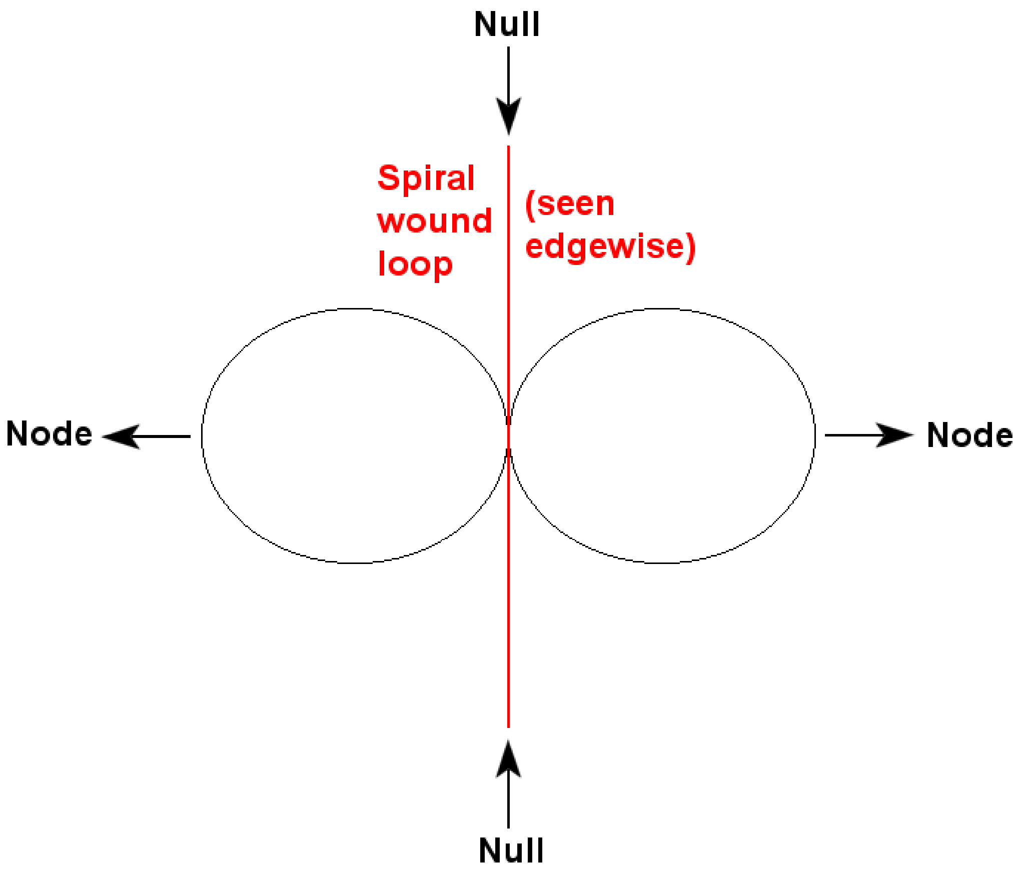
The reception pattern can be visualized as a figure 8 pattern, with the loop most sensitive to anything inside the "8", and less sensitive to anything outside the "8". The actual reception pattern is many times the physical size of the loop - the loop size was increased orders of magnitude in the figure to show the physical construction and orientation. The term "node" refers to the areas of highest sensitivity, and "null" to the areas of lowest sensitivity. While the nodes of loop antennas are quite broad, the nulls can be very sharp. A signal source perpendicular to the axis of an edge wound loop may not be received at all!

Spiral Wound

A spiral wound loop consists of a flat spiral of wire, where each turn is enough larger than the previous to fit snugly around it:



The reception pattern of a spiral loop is shown below:



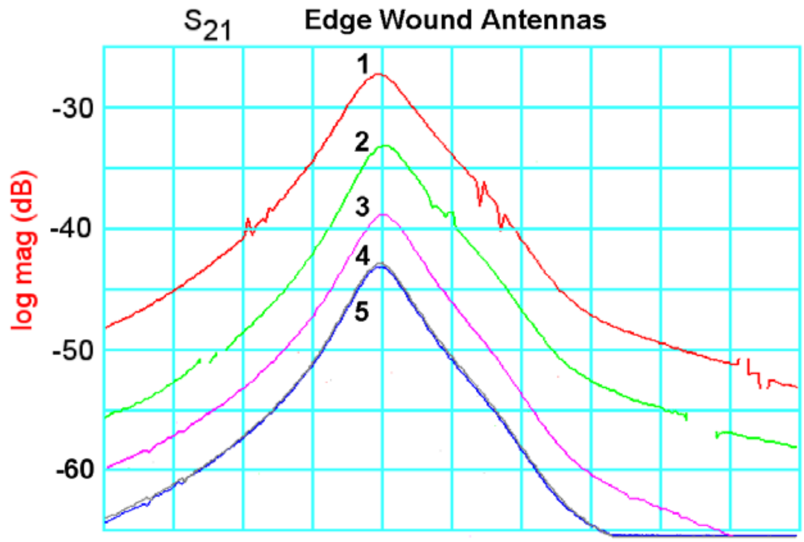
A spiral loop is least sensitive to signals received in its plane.

Loop Antenna Tru-isms Proved

I recently had occasion to do extensive loop antenna testing in a controlled, laboratory environment. I was working at a higher frequency, but the mathematics and behavior of loops is identical to the behavior of AM loops. Because I was dealing with very small loops, I could make as many loop antennas as I wanted - and they were easy to deal with.

Bigger is Better

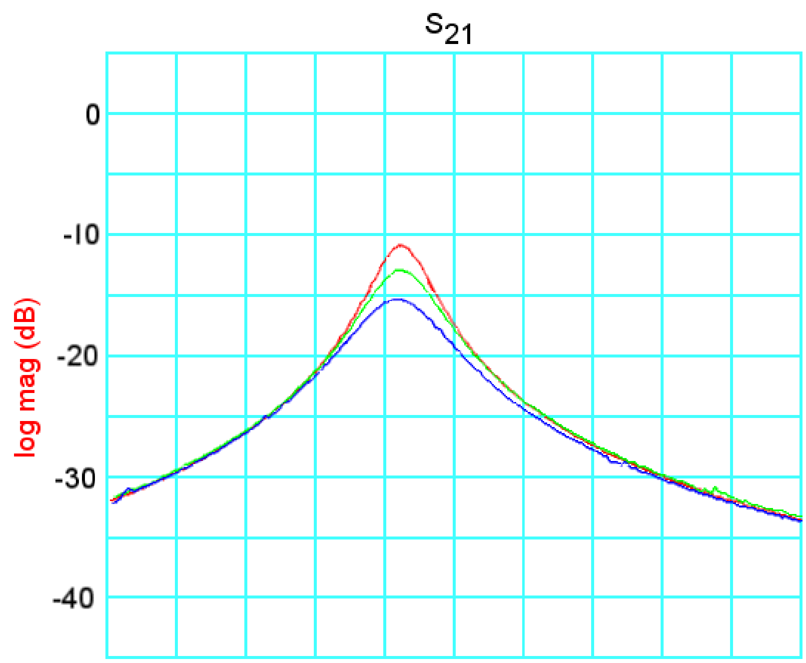
We all know that the bigger the loop, the more sensitive it is. Here is the proof:



This data, taken from a nework analyzer, shows the results for rectangular, edge wound loops varying from a single turn (3.775 inch edge) to 5 turns (0.32 inch edge), which translates to an area ranging from 14 to 0.1 in^2. All were the same inductance, and resonated with almost the same value of capacitance. It is interesting that the area varied over such a wide range. It is also very interesting that the received signal strength changed in increments of about 5 dB, except for the 4 - 5 turn increment where the mechanics of the loops were increasingly difficult to control (the bending radius of 20 AWG wire made both loops almost identical). Extrapolating this down in frequency and up in size, each time the area is increased enough to require one less turn, you can expect a power increase in the received signal of 5 dB, which is a jump of 3.16:1. To receive really weak signals - make the loop **BIG**! Incidentally, I had almost identical results for spiral wound loops.

Increasing the Q Increases the Sensitivity

I have recently revised this conclusion! Science is a self-correcting discipline, and as it becomes possible to perform more carefully controlled tests, the results can often change.



As expected the Q and sensitivity increased with larger guage wire. An alternative to larger guage wire is Litz wire (available at Skycraft. The best way to get more sensitivity, however, is still to increase the loop size. Increasing the loop Q too much has a consequence. Tom Polk, a good friend of mine, and crystal / transistor radio expert clued me in to one fact: if you make the Q of a loop too high, you are going to limit your audio frequency response. This may be acceptable if you want to separate out closely packed stations, but be aware of the effect. If you are making a remote tuned loop that will be mounted outdoors, Litz wire may not be your best choice. It corrodes outside - FAST!

Construction Articles

My articles form a sort of chronological "journey" of loop construction projects and things I learned along the way - read them in the order listed below to learn along with me!

- The Four Foot Loop
- The Two Foot Loop
- The Folding Loop
- The 3 Foot Portable Ribbon Cable Loop
- The Umbrella Loop
- Styrofoam Loops

Where to from here?

- I wonder if I couldn't make a loop using a flat variation of a Hoberman Sphere. I have seen an awesome flat "Hoberman-like" structure used to support large banners at "Radio Disney" live remotes my daughter goes to. (Obviously we go to the remotes - as KMKI AM 620's fabulous signal makes it an ideal test station from Lubbock, TX). I can't find anything on the web about the display frame - since it is trade show type stuff it may be expensive. But - I have the measurements, perhaps I can find a way to make a loop frame from it.

Loop Antenna (and Related) Links

- Super Antenna plans
- Loop Aerials & ATU's
- Magnetic Loop Antenna Experiments by Jeff Imel, KB9ZUR
- AM Antennas - ABC Reception Advice Website
- LOOP
- Amidon Associates Ferrite Rods, Bars, Plates and Tubes
- Ferrite Rods, Bars, Plates and Tubes
- High-Gain Preamp
- A Magnetic Loop Antenna for Shortwave Listening (SWL) by KR1ST
- Receiving Loop Theory - N4YWK
- Magnetic Loop antenne's.
- RadioIntel.com - THE WOODEN ALTAZIMUTH HOOP LOOP
- Radio Netherlands Media Network An Introduction to Long Distance Medium Wave Listening
- Dave's Loop Antenna Page
- Air Variable Capacitors, Shafted
- RECEIVING LOOP AERIALS FOR 1.8 MHz
- LOOP DISCUSSION!
- Better AM Radio Reception
- GCC Loop Antenna Design There are now two Yahoo loop antenna groups - this one has the original content
- Yahoo! Groups loopantennas
- ARES RACES Antenna Projects
- The Ultimate AM Antenna
- Doug's R-E Loop Article Page
- Reception techniques An easy loop
- amandx-loop
- AM-FM Reception Tips
- DX News, Tips and Information page
- Joe Carr's Tech Notes
- Rectangle Loop
- Loop Page
- AM Radio Reception
- Coax-Shielded Loop Antenna for 80 - 40 meters
- a Ten Foot Receiving Loop For Low Frequency Dx Work
- Rahmenantenne
- Super Antenna plans
- Universal LF-MF Preamp
- Receiving Loop Theory - N4YWK
- Re Tuned Loop For AM Radio
- A conveniant AM loop antenna
- Loop Antenna Page
- Loop Antenna
- All About Loops - for traffic detection
- Dave's Loop Antenna Page
- Rectangle Loop
- Interference-reducing Antenna page
- 903 383-7047 STORMWISE Ferrite Rods Long Ferrite Rods VLF Antenna Element Big Ferrite Rods
- The Black Hole Antenna
- http--www.wenzel.com-pdffiles-antenna1.pdf

- AM Radio Antennas

Feel free to email me at **brucec@mindspring.com** if you have any material that will help to improve this page! Sorry for the unclickable graphic - spammers are scum that harvest email addresses from web pages.

Junior's Project

MORSE CODE PRACTICE OSCILLATOR

A simple first project for young newcommer

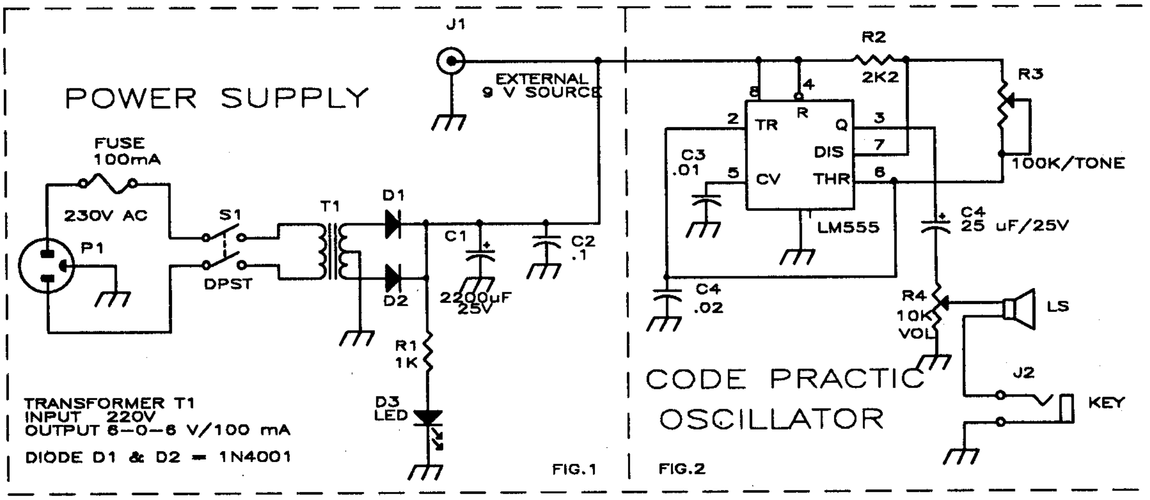


FIG.1 FIG.2

If you are a new comer trying to enter the world of amateur radio or an experienced VHF'r planing to upgrade your licence you have to learn Morse code and for this you need a Code Practice Oscillator or in short a C.P.O. If you are not successful in your efforts in borrowing or getting it gifted to you, you might aswell make one for yourself. It is very easy and can be a very useful first home brewing project in case you are new to this hobby.

The complete circuit of the CPO is given in the fig.1., The circuit is divided in to two parts, The second portion is the oscillator which works on direct current (D.C). of any value between 6 to 12 Volts and the first portion is the power supply (commonly known as Battery eleminator) which converts 230 Volt Alternating Current (A.C.) from your house wiring, in to 9 Volt D.C. which is fed to the oscillator. If you have a Battery eliminator of any voltage between 4.5 to 12 volts you can use it to run the oscillator and need not make the first portion.

You can also run the oscillator on a 6 or 9 volt dry battery of the type normally used in torch, but you may find that running the CPO on torch cells usually causes heavy strain on pocket money. Running a CPO, a radio or to say any other electronic gadget on a battery eliminator is always cheaper in the longer run but making a battery eliminator requires interconnectiong transformer, switches, power cord and power plug which carry dangerous high A.C. Voltages(230 V. AC.) and unless you have some senior person say your teacher or a senior ham guiding and supervising your project, you should avoid making the first portion of the cicuit and use torch cell instead. When dealing with high voltages SAFETY ALWAYS COMES FIRST. Don't do anything alone and whenever in doubt "ASK" a seinor person.

Now move to the second part, the actual oscillator circuit is all enclosed inside the small 8 Pin (legs) Integrated Circuit (I.C.) LM555. This is commonly known as "Tripple 5". The frequency of oscillation or the tone of the sound is controlled by the fixed resistance R2, variable resistance R3 and the capacitor C4. By varying the variable resistance R3 you can change the tone to your liking. The output of the oscillator is available from Pin 3 of the IC and is supplied to the loudspeaker via capacitor C4 and variable resistance R4. The capacitor C4 is used to prevent DC from Pin 3 from flowing in to the loudspeaker and the R4 is used to vary the volume. The Morse key is connected to the jack J2. Whenever the key is pressed the second terminal of the loudspeaker is connected to common ground and oscillating current flows through it, producing sound. In this circuit the oscillator is always running and it is the speaker which is switched in and out. Even when the key is not pressed and no sound is coming, the oscillator is still drawing some current. Therefore to avoid the battery being discharged unnecessarily disconnect it when the CPO is not in use.

The complete circuit is assembled on a small printed circuit board (PCB) and the overall pictorial view of the interconnections is shown in the Figure 3. If you are new to electronics try to find more information about the components used in the circuit, where they are available, how much they cost etc. and from where help might be available. Before starting any constructional project, collecting sufficient money to buy all the compontnts is a major obstacle, so start saving and if your parent are very strict about the pocket money than remember saving on ice creams and chocolates always makes a young ham healthy, wealthy and wise. In case your are living in some remote area where electronic components are just not available, don't panic, we will help you in getting all the components. Next time we will look at the actual construciton of the CPO in detail.

Crystal Set Mobile

By Al Klase – N3FRQ – December 2006

Back in the 1990's there was a Yahoo Internet "club", devoted to crystal radio development called "The Ferrite Core." One of the perennial topics of conversation was the difference between operating a crystal set near high-power stations as opposed to a more rural setting. Someone, who had read Aesop's Fables likened this to "The City Mouse and the Country Mouse." The country mouse needed a sensitive radio hooked to a large antenna, but could faintly hear distant stations without a lot of interference. The city mouse's crystal set could drive a loudspeaker using only the bed springs for an antenna, but he couldn't hear much beyond the city limits.

I've spent most of my life as a country mouse, but recently I've been frequently finding myself in Jersey City. Indeed, crystal set operation is very different there. Short antennas work pretty well, and even my nearly-deaf rocket radio picks up multiple stations. It's even possible to operate a properly designed set with the antenna terminal connected to ground with the headphone cord and listener serving as the actual antenna.

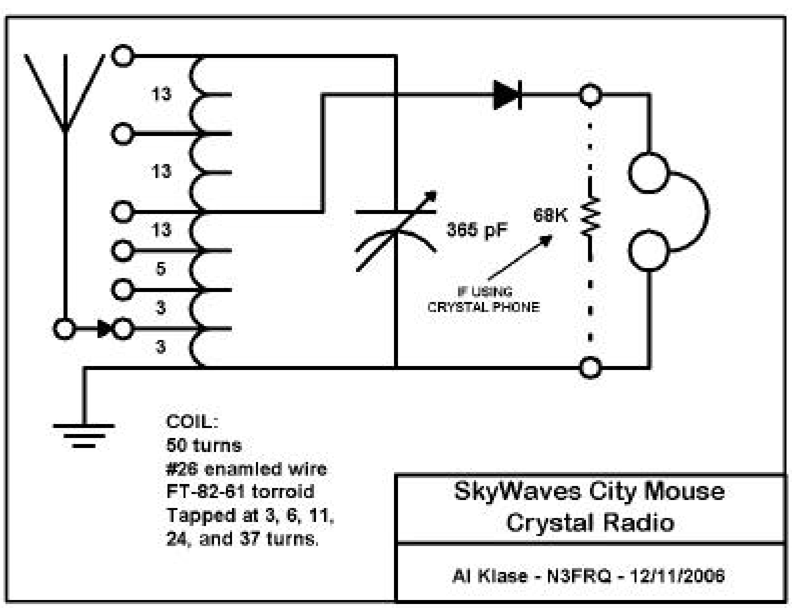
I decide to apply what I learned down town to a couple of radios I was building as Christmas presents. The circuit is very similar to the NJARC Pretty-Good Crystal Set, but the coil is wound on a ferrite toroid to save space, and there are additional antenna taps on the "high end" of the coil to better accommodate short antennas.

I recently found myself in Maywood, near Hackensack, with some time to kill while Peggy rehearsed before a Sunday-afternoon concert. I took the city mouse for a walk in a nearby park. With 20 feet of wire, 5 feet in the air, and the ground wire clipped to a metal park bench, I could comfortably choose from five or six stations. I could still hear the Jets game on WABC, with just the ground connected to the antenna terminal.

Still having some time to waste, I picked up a four-foot stick as I returned to the car. I grounded the set to the ignition key, and extended the antenna wire out the sunroof with the stick. Sure enough, the Jets were still ahead. I wound the rest of the wire around the stick as a loading coil.

The ugly stick

After an enjoyable concert (The Four Seasons and a Brandenburg Concerto w/harpsichord), I listened to the crystal set down the turnpike through the Meadow Lands, past all the towers, all the way home. I think most were on night-time power by now, as none were obnoxiously loud. I need to try that again, in broad daylight, with a speaker.



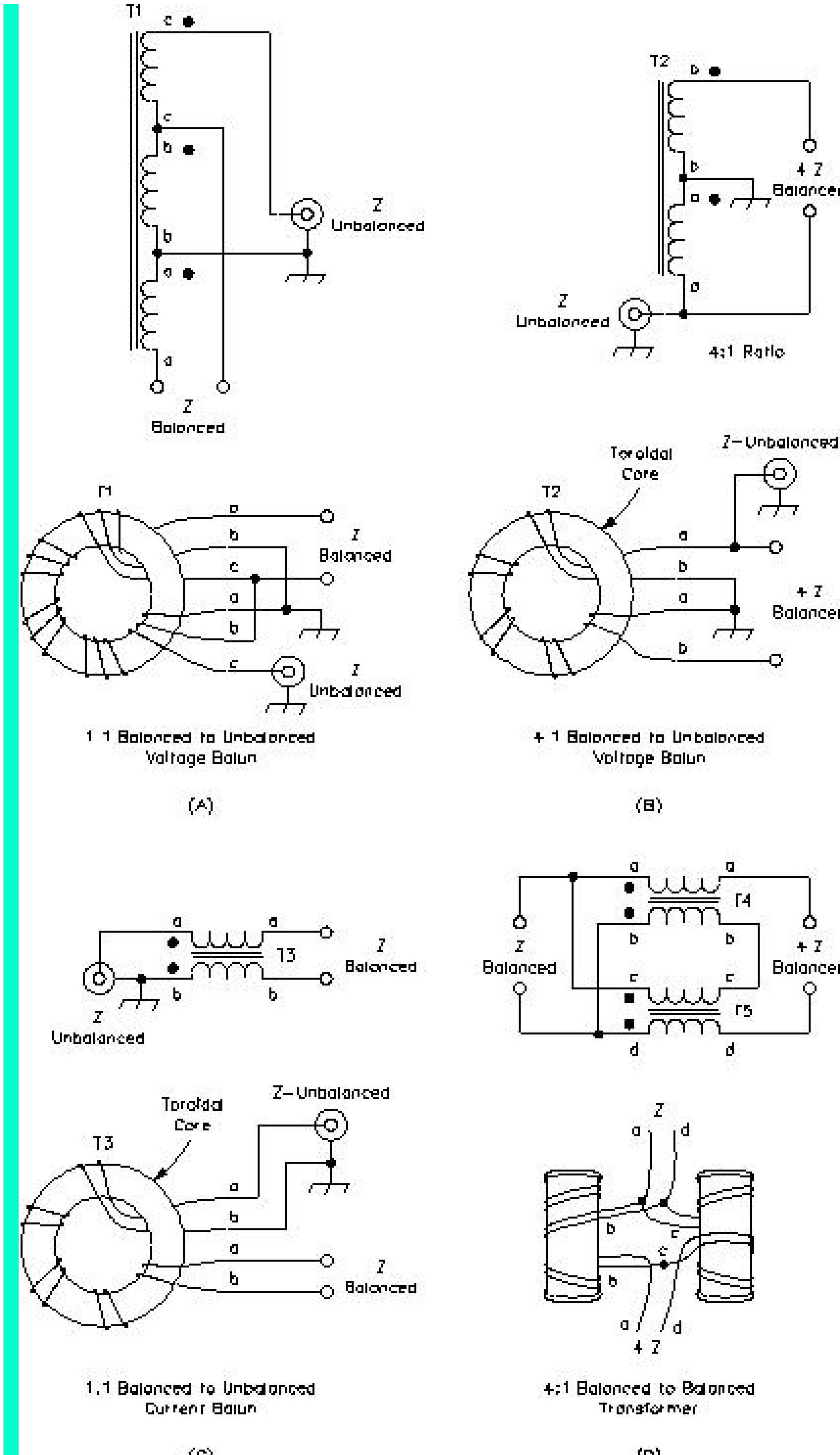
Broadband Baluns

At HF and even at VHF, broadband baluns are generally used nowadays. These can be divided into two distinct categories: voltage baluns and choke (or current) baluns. Examples of the two types of baluns are shown in Fig 19.13.

The voltage baluns of Fig 19.13A and Fig 19.13B cause equal and opposite voltages to appear at the two output terminals, relative to the voltage at the "cold" (coax cable ground) side of the input. If the two antenna halves are perfectly balanced in impedance with respect to ground, the balun will force the voltages to be equal, and the currents flowing from the balun's output terminals will be equal and opposite. No antenna current will flow on the feed line, and the feed line will not radiate. If the load is balanced, the 1:1 voltage balun of Fig 19.13A performs exactly the same function as the current balun of Fig 19.13C, as there is no net current in winding b. If the antenna isn't perfectly symmetrical, however, unequal currents will appear at the balun output, despite equal voltages, causing antenna current to flow on the line, an undesirable condition leading to line radiation.

Another potential shortcoming of the 1:1 voltage balun is that the windings appear across the line. If the windings have insufficient inductive reactance (a common problem, particularly near the lower-frequency end of its range), the system SWR will be degraded. The choke, or current balun, is generally recommended for use at the junction of the antenna and feed line. However, voltage baluns are still commonly used in this application and serve a useful function if the user is aware of their shortcomings.
While voltage baluns cause equal and opposite voltages to appear at their outputs, choke or current baluns force equal and opposite currents to flow. The result is that currents radiated back onto the transmission line by the antenna are effectively reduced, or "choked off," even if the antenna is not perfectly balanced. If winding inductive reactance becomes marginal at lower frequencies, the balun's ability to eliminate antenna currents is reduced, but (for the 1:1 balun) no winding impedance appears across the line.

For either type of balun, if induced current on the line is a problem, perhaps because the feed line must be run in parallel with the antenna for some portion of its length, additional baluns can be placed at approximately 1/4-l intervals along the line. Current baluns are particularly useful for feeding asymmetrical antennas with balanced line.



Broadband Balun Construction

Either type of broadband balun can be constructed using a variety of techniques. Construction of choke (current) baluns is described here. The objective is to obtain a high impedance for currents that tend to flow on the line. Values from a few hundred to over a thousand ohms of inductive reactance are readily achieved. These baluns work best with antennas having resonant feed-point impedances less than 100 W or so (400 W for 4:1 baluns). This is because the winding inductive reactance must be high relative to the antenna impedance for effective operation. A rule of thumb is that the inductive reactance should be four times higher than the antenna impedance. High impedances are difficult to achieve over a wide frequency range. Any sort of transformer which is operated at impedances for which it was not designed can fail, sometimes spectacularly.

The simplest construction method for a 1:1 balun for coaxial line is simply to wind a portion of the line into a coil. See Fig 19.14. This type of choke balun is simple, cheap and effective. Currents on the outside of the line encounter the coil’s impedance, while currents on the inside are unaffected. A flat coil (like a coil of rope) shows a broad resonance that easily covers three bands, making it reasonably effective over the entire HF range. If particular problems are encountered on a single band, a coil that is resonant at that band may be added. The coils shown in Table 19.4 were constructed to have a high impedance at the indicated frequencies, as measured with an impedance meter. Many other geometries can also be effective. This construction technique is not effective with open-wire or twin-lead line because of coupling between adjacent turns. An air-core 4:1 choke balun is shown in Fig 19.15.

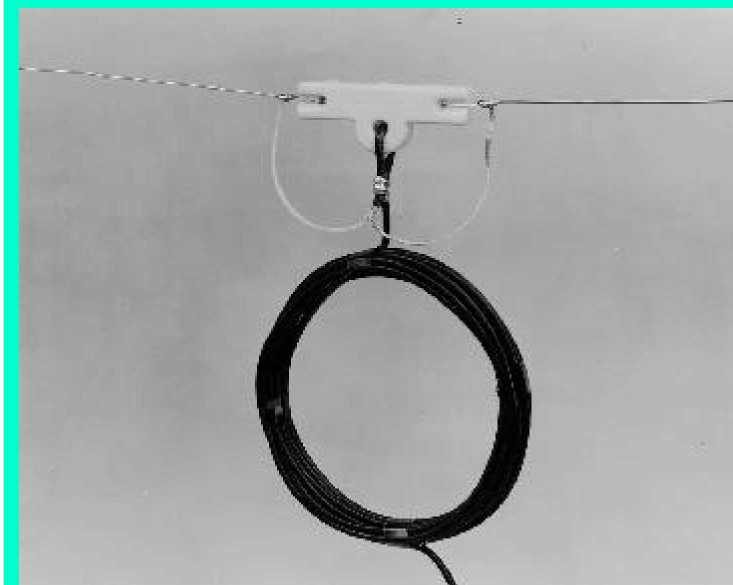


Fig 19.14 — RF choke formed by coiling the feed line at the point of connection to the antenna. The inductance of the choke isolates the antenna from the remainder of the feed line.

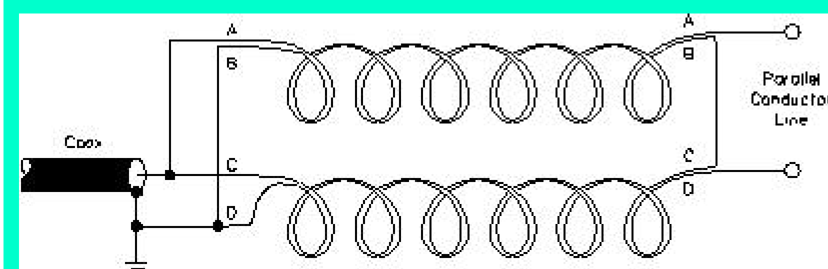


Fig 19.15 — 4:1 air-core current balun. This balun is rarely encountered nowadays, having been supplanted at HF by more compact broadband balun transformers wound on toroidal cores.

Ferrite-core baluns can provide a high impedance over the entire HF range. They may be wound either with two conductors in bifilar fashion, or with a single coaxial cable. Rod or toroidal cores may be used. Current through a choke balun winding is the “antenna current” on the line; if the balun is effective, this current is small. Baluns used for high-power operation should be tested by checking for temperature rise before use. If the core overheats, add turns or use a larger or lower-loss core. It also would be wise to investigate the imbalance causing such high line antenna currents.

Type 72, 73 or 77 ferrite gives the greatest impedance over the HF range. Type 43 ferrite has lower loss, but somewhat less impedance. Core saturation is not a problem with these ferrites at HF; since they overheat due to loss at flux levels well below saturation. The loss occurs because there is insufficient inductive reactance at lower frequencies. Eight to ten turns on a toroidal core or 10 to 15 turns on a rod are typical for the HF range. Winding impedance increases approximately as the square of the number of turns.

Another type of choke balun that is very effective was originated by M. Walter Maxwell, W2DU. A number of ferrite toroids are strung, like beads on a string, directly onto the coax where it is connected to the antenna. The “bead” balun in Fig 19.16 consists of 50 FB73-2401 ferrite beads slipped over a 1-ft length of RG-303

coax. The beads fit nicely over the insulating jacket of the coax and occupy a total length of 9-1/2 inches. Twelve FB-77-1024 or equivalent beads will come close to doing the same job using RG-8A or RG-213 coax. Type-73 material is recommended for 1.8 to 30 MHz use, but type-77 material may be substituted; use type-43 material for 30 to 250 MHz.

Fig 19.16 — W2DU bead balun consisting of 50 FB-73-2401 ferrite beads over a length of RG-303 coax. See text for details.

The cores present a high impedance to any RF current that would otherwise flow on the outside of the shield. The total impedance is in approximate proportion to the stacked length of the cores. The impedance stays fairly constant over a wide range of frequencies. Again, 70-series ferrites are a good choice for the HF range; use type-43 if heating is a problem. Type-43 or -61 is the best choice for the VHF range. Cores of various materials can be used in combination, permitting construction of baluns effective over a very wide frequency range, such as from 2 to 250 MHz.

Table 19.4 — Effective Choke (Current Baluns)
Wind the indicated length of coaxial feed line into a coil (like a coil of rope) and secure with electrical tape. The balun is most effective when the coil is near the antenna. Lengths are not critical.

Single Band (Very Effective)

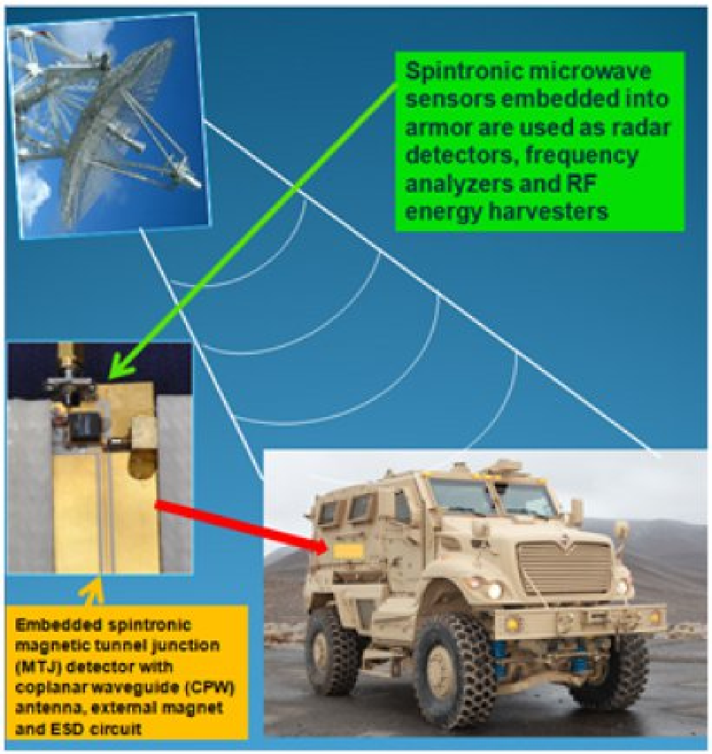
MHz	RG-213, RG-8	RG-58
3.5	22 ft, 8 turns	20 ft, 6-8 turns
7	22 ft, 10 turns	15 ft, 6 turns
10	12 ft, 10 turns	10 ft, 7 turns
14	10 ft, 4 turns	8 ft, 8 turns
21	8 ft, 6-8 turns	6 ft, 8 turns
28	6 ft, 6-8 turns	4 ft, 6-8 turns

Multiple Band

MHz Freq	RG-8, 58, 59, 8X, 213
3.5-30	10 ft, 7 turns
3.5-10	18 ft, 9-10 turns
14-30	8 ft, 6-7 turns

Scientists Develop Novel "Spintronic" Sensors for the Army

By Dr. Elena N. Bankowski and Dr. Thomas J. Meitzler, U.S. Army TARDEC June 3, 2015



SHOW CAPTION + 1 / 5

In quantum mechanics, spin is an intrinsic form of angular momentum carried by elementary particles. Spintronics is "A branch of physics concerned with the storage and transfer of information by means of electron spins in addition to electron charge as in conventional electronics." Spin-based electronics focuses on devices whose functionality is based primarily on the spin degree of freedom of the carriers. This is in contrast to conventional electronics, which exploits only the charge of the carriers. Using either the spin in tandem with the charge or alone, spintronics has some advantages over conventional semiconductor electronics, including higher integration density, non-volatility, decreased power dissipation and faster processing speeds.

Based on our landmark research, the authors received a 2013 Army Outstanding Technical Research and Development Achievement Award for the "Spintronic Radar Detectors for Multifunctional Armor." We are continuing our research, development and integration of the fast and very accurate spintronic sensor system for detection and analysis of radar threats for ground combat vehicles. The system is based on arrays of nano-scale radiation-hard frequency-selective spintronic microwave diodes (SMD). The spintronic radar detectors and planar microwave antennas could be embedded directly into the vehicle's armor without compromising its structural integrity as depicted in Figure 1.

U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) researchers have made significant contributions to spintronic microwave detector development theory in collaboration with the research group led by Physics Department Professor Andrei Slavin at Oakland University, Rochester, MI. Through crucial collaboration, we co-developed mathematical models and computer programs for optimization of parameters and geometrical dimensions of future spintronic detectors to achieve maximum

sensitivity. Ten spintronic microwave detectors have been built based on theoretical calculations and computer modeling by the research group led by Professor Ilya Krivorotov at the University of California at Irvine.

The structure of a Spintronic Radar Detector is shown in Figure 2. The SMD receives a microwave signal from a planar antenna. This signal creates a resonance magnetization precession in the "free layer" of a nano-scale SMD. A precession signal is detected by giant magneto-resistance effect. Radar detector (array of SMDs with different in-plane shapes and, thus, different resonance frequencies) works as a fast — ~500 nanoseconds (ns) — passive spectrum analyzer.

The authors, in collaboration with university spintronic researchers, developed a new spintronic detector design and received United States Patent No. US 8,860,159 B2, for Spintronic Electronic Device and Circuits, on Oct. 14, 2014, for their invention. None of the prior spintronic sensors utilized Ta, Ru and CuN layers, which were used to produce a very smooth (small crystallographic grain size) conductive bottom layer. This was necessary for deposition of a pinhole-free, magnetic tunnel junction (MTJ) on top. None of the prior art spintronic sensors described the layers of Ta, Ru and Cu on the top, which were needed for making a reliable contact to the top lead of the tunnel junction.

The SMD schematic shown in Figure 3 depicts a horn antenna used to transmit the incoming microwave frequency signal. The coplanar waveguide (CPW) antenna (#1) is used to receive this signal and feed it to the spintronic detector (#2).

Turning the set screw (#5) changes the distance from the magnet (#6) to the detector and varies the magnetic field. This changes the spintronic sensor's resonance frequency, based on the MTJ and SMD sensitivity. The spintronic detectors are tuned for maximum sensitivity. The experimental results have demonstrated that SMDs coupled to CPW antennas were capable of receiving external microwave signals in a laboratory experiment performed in the anechoic chamber developed in TARDEC's Electrified Armor Laboratory. Figure 4 depicts the experimental setup inside the anechoic chamber.

The next step in developing the novel spintronic radar detectors is the integration of SMD arrays into protective surfaces of ground vehicles. The authors have begun measuring the effects of various protective materials on the SMD detector with CPW antenna. Two types of materials, Alumina and silicon carbide (SiC), were placed between the transmitting horn antenna and the receiving CPW antenna and the signal strength was measured. Figure 5 shows the detector plots. More work towards system integration is planned. The objective is to develop prototype spintronic devices or systems and nano-engineered metamaterials for radar detection, signature management and active-smart armor protection systems. Ultimately, these devices and materials will be integrated into ground combat vehicles.

The fast and reliable detection of radar threats will provide sufficient time to undertake the relevant counter-measures (e.g., active jamming of the enemy radar, reposition of a sacrificial armor component, etc.) which will lead to greatly improved survivability of ground combat vehicles. The characteristic time of frequency determination will be substantially shorter than the return propagation time of a transmitted radar or control pulse that typically is in the order of a microsecond.

The ultrafast detection and spectral analysis of enemy radio transmissions is vital for survivability applications to allow achieving the active interference with these signals on the time scale of the signal propagation time. This problem arises in anti-radar defense (to detect incoming radar pulses and jam them or determine the radar position), counter-terrorist activity (to detect and jam triggering microwave signals of radio-triggered explosive devices) and military intelligence (to intercept and/or jam radio messages sent using the frequency-hopping spread spectrum method). In all these tasks the detector should be able to determine the frequency of a microwave signal very fast — on sub-microsecond time scale — to take appropriate counter-actions during the time intervals comparable with the time of the pulse propagation.

Editor's Note: If you'd like to establish a dialog with TARDEC scientists Dr. Elena Bankowski and Dr. Thomas Meitzler, please contact them at elena.n.bankowski.civ@mail.mil or thomas.j.meitzler.civ@mail.mil, respectively.

du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Sunday, November 12, 2017

Home Brew Static Wick

By theory, this device bleeds excess voltage potential of your tower and thus minimize the risk of direct lightning strike. This device is totally different from the lightning arrester and though it does not guarantee 100% protection but there is no harm in trying.

I made my wick from fine stainless wire cut 12 inches long. I prepared 15 pieces of these wires then I folded it in half and crimped them together in a 3/8" stainless tubing. The more pointed tips, the better it perform so it is your option. The wick can be attached to the highest portion of your tower and must be provided with grounding below. 73 de du1vss

Posted by hevirred at 7:18 PM

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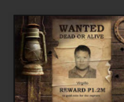

hevirred

Ham since 2000.

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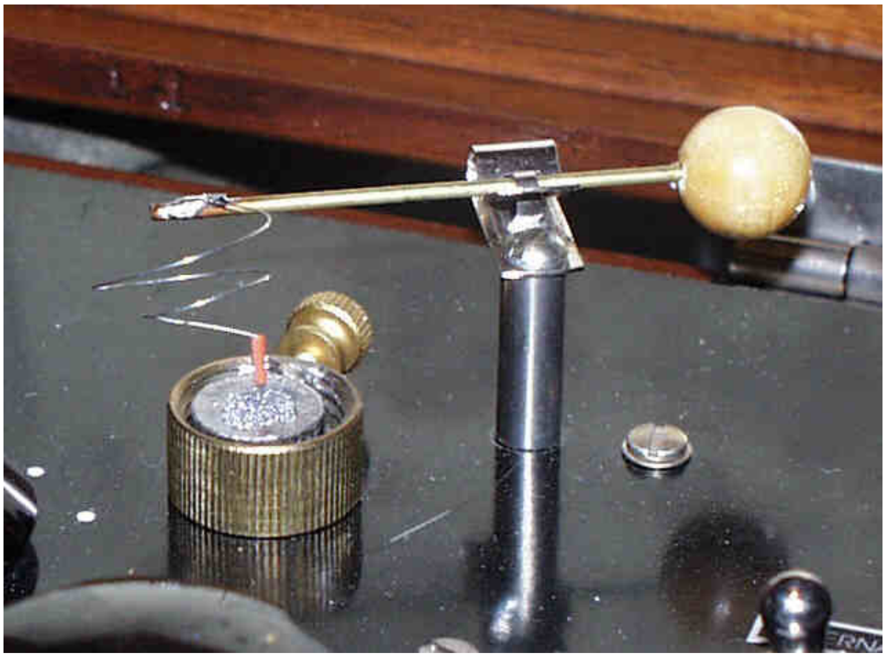
Homebrew Detector Stand

Crystal detector stands have become expensive and hard to find. Here's a highly satisfactory design inspired by Elmer Osterhoudt that you can make without needing a machine shop:



The heart of this stand is a common Fanestock clip. These are the old fashioned spring-type wire terminals. If you can't dig one out of the junk box, Antique Electronic Supply will sell you a life-time supply. The rod is 1/16" brass from the hobby shop. The 1/2" wooden bead is a standard craft store item. The catswisker is a piece of 0.008" steel guitar string soldered to the rod. The end is clipped at an angle to provide a sharp point. I glue a small piece of brightly colored wire insulation near the end of my cw's to improve visibility.

The Fanestock clip is mounted with a 3/4" through spacer (unthreaded) and a long #6 machine screw. Below the panel there is a solder lug, a compression spring, and a nut. I use elastic stop nuts to maintain moderate spring tension without coming loose. Two ordinary nuts jammed against each other will work as well.

This arrangement gives the catswisker three degrees of movement to reach any part of the crystal. The thin spring-steel wire allows the delicate touch required to get good performance out of galena.

The crystal holder shown was made from lamp parts. I soldered a 4-40 nut inside the side of the cup to provide good threads for the thumb screw. A simple U-bracket of tin or hobby brass works as well.

HOME

Paul Harden, NA5N

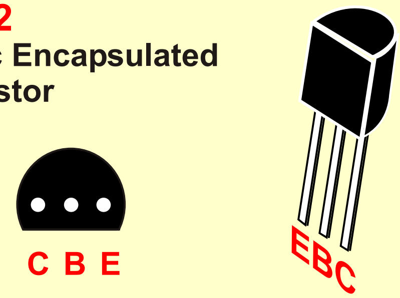
The Handyman's Guide to – UNDERSTANDING TRANSISTOR DATA SHEETS & SPECIFICATIONS

The QRPer's Favorite

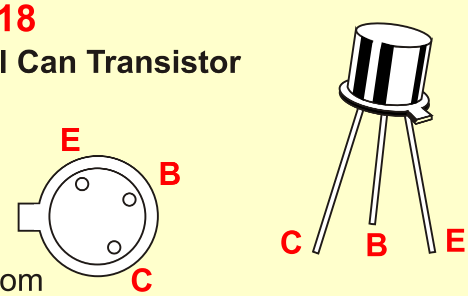
GENERAL PURPOSE NPN TRANSISTORS

2N2222
2N3904
2N4401
MPS2222
MPS3904

TO–92
Plastic Encapsulated Transistor

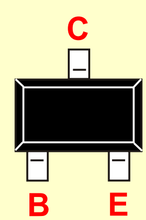


TO–18
Metal Can Transistor



SOT-23
Surface Mount Transistor

MMBT2222LT1
MMBT3904LT1
MMBT4401LT1



Introduction

*The most common bipolar junction transistors (BJT) used by hobbyists and QRPers are the **2N2222**, **2N3904** and **2N4401**. These NPN transistors have similar characteristics, and perform well at HF frequencies.*

This tutorial explains how to "read" the data sheets on these devices and understand the specifications – which will enable you to interpret data sheets for other devices as well.

The manufacturer's data sheets contains information in the following general categories:

1. Maximum (Breakdown) Ratings
2. "On" Characteristics
3. Small Signal Characteristics
4. Switching Characteristics

1. Maximum (Breakdown) Ratings

The maximum ratings are provided to ensure that the voltages and currents applied do not damage or cause excessive heating to the device. The maximum ratings for the 2N2222, 2N3904 and 2N4401are shown in **Table 1**. The voltages, currents and power dissipation listed should *not be exceeded* to prevent damage to the device.

VCEO is the maximum **collector-emitter voltage** and **VCBO** is the maximum **collector-base voltage**. Fortunately, these breakdown voltages are well above the typical 12v used in most QRP applications.

This is not the case with **VEBO,** the **maximum emitter-base voltage**, typically 5–6v. If exceeded, this can cause a physical breakdown of the base junction, destroying the

Table 1 – MAXIMUM (BREAKDOWN) RATINGS

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
Collector–Emitter	VCEO	30v	40v	40v	40v	40v
Collector–Base	VCBO	60v	75v	60v	60v	60v
Emitter–Base	VEBO	5v	6v	6v	6v	6v
Max. Coll. Current	Ic	600mA	600mA	200mA	600mA	200mA
Power dissipation	Pd	625mW	625mW	625mW	625mW	225mW

transistor. In a circuit, the biasing scheme sets the base-emitter voltage, VBE, to be safely below VEBO. However, in large-signal applications, VBE must include the DC base bias *and the peak voltage of the signal* to ensure VEBO will not be exceeded.

Collector Current, Ic(max), is the other maximum rating to be closely followed. Collector current exceeding Ic(max) can damage the transistor, due to excessive current through the device, initiating thermal runaway – destroying the collector-emitter junction. The destruction of a transistor in this manner is technically called *catastrophic substrate failure* for good reason!

Most QRP circuits are usually biased for well below Ic(max). Vbe(max) and Ic(max) are generally a concern only in large-signal applications, such as RF drivers, PA stages, and some oscillator circuits.

2. ON CHARACTERISTICS

These specifications define the DC performance of the device while it is forward biased (Vbe ≥0.7v), causing collector current to flow, or "on." The DC Characteristics in **Table 2** are not absolute design values, but rather *test values* as measured by the manufacturer. This is why the data is listed with the test conditions, such as "Ic=1mA, VCE=10v."

HFE is the *measured* **DC current gain** of the transistor (see *Rule of thumb for HFE*). It is used for biasing the device in the linear region – primarily class A. Most data sheets provide HFE at two different collector currents, usually 1 and 10mA. Since most QRP circuits are biased for Ic ≤5mA (to conserve battery drain), HFE at Ic=1mA is typically used.

HFE also varies from transistor–to–transistor. This is why the data sheets list both HFE (min) and HFE (max). The manufacturer tested a large batch of 2N2222s and determined that hfe ranged from 50 (HFE **min**) to 150 (HFE **max**) at Ic=1mA, as shown on the data sheets (**Table 2**). Statistically, most transistors will fall between 50 and 150, or about HFE=100. This is why most design guides will recommend using a value of HFE=100 for bias calculations. Since the 2N3904 has a higher DC current gain, often HFE=150 is recommended for that device.

HFE min. and max, at Ic=1 and 10mA, can be plotted on a logarithmic graph (lines 1 and 2 on **Fig. 1**). The average

Rule of thumb for <u>VEBO</u>: VEBO(max) or Vbe(max) for most general purpose BJTs is 5–6v – the *maximum* emitter-base voltage. Don't forget to include the peak voltage of the AC signal!

Rule of thumb for <u>Ic(max)</u>: There isn't one! The only safe way to know the maximum Ic for a transistor is to consult the data sheets.

Table 2 – DC "ON" CHARACTERISTICS

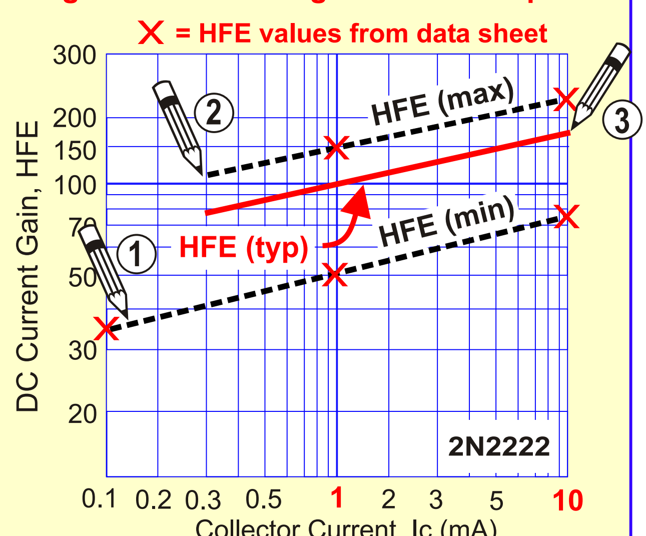
		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
DC Current Gain, HFE						
Ic= 0.1mA, VCE=10v	HFE Min.	35	35	40	20	40
Ic=1.0 mA, VCE=10v	HFE Min.	50	50	70	40	70
	HFE Max.	150	150	200	—	200
Ic= 10 mA, VCE=10v	HFE Min.	75	75	100	80	100
	HFE Max.	225	250	300	—	300
Collector-Emitter Saturation Voltage, VCE(sat)						
Ic= 150mA, IB= 15mA	VCE(sat)	0.4vdc	0.3vdc	0.3vdc†	0.4vdc	0.2vdc†
Base-Emitter Saturation Voltage, VBE(sat)						
Ic= 150mA, IB= 15mA	VBE(sat)	1.3vdc	1.2vdc	0.85vdc	0.95vdc	.85vdc†

† Ic=50mA, IB=5mA on 2N3904

Rule of thumb for <u>HFE</u>:
Conventions used in electronic literature:

HFE or **hFE** (upper case letters)
is the ***DC Current Gain***
Hfe or **hfe** (lower case)
is the ***AC current gain***

Fig. 1 – Constructing an HFE vs. Ic plot



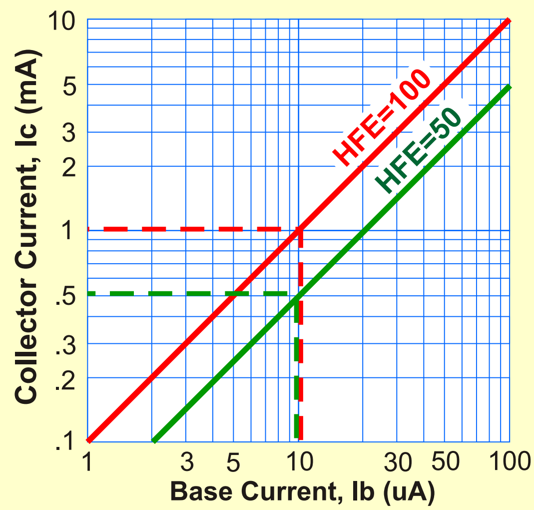
value, HFE typ., can then be drawn (line 3, **Fig. 1**). This gives you HFE (typ) for various collector currents.

The value used for HFE is not critical. Using HFE=100, or even the conservative value of 50, will work 99% of the time. Therefore, one scarcely needs the data sheets for the DC characteristics, as the typical HFE = 100 at Ic=1mA is valid for most general purpose NPN transistors. **Fig. 2** shows **Ib vs. Ic** for HFE at 50 and 100.

Saturation voltages, VCE(sat) and **VBE(sat)**, defines the transistor behavior *outside* the linear operating region, that is, in the saturated region. This is of interest when operating the transistor as a saturated switch. The keying transistor in a transmitter, forming the +12v transmit voltage on key–down, is an example of a saturated switch.

Rule of thumb for HFE:
Most general purpose NPN transistors have a DC HFE = 100 (typ) and thus used in most biasing equations for DC and low frequencies.

Fig. 2 – Ic vs. Ib defines HFE



At Ib=10uA, Ic=0.5mA @ HFE=50
At Ib=10uA, Ic=1.0mA @ HFE=100

3. SMALL SIGNAL CHARACTERISTICS

The small-signal characteristics describe the AC performance of the device. There is no standardized industry definition of small-signal (vs. large-signal), but is generally defined where the *AC signal* is small compared to the DC bias voltage. That is, the signal levels are well within the linear operating region of the transistor.

The small signal characteristics include:

1) gain bandwidth product (**Ft**)
2) the AC current gain (**hfe**)
3) input and output impedances (**hie** and **hoe**)
4) input and output capacitances (**Cibo** and **Cobo**)
5) the noise figure (**NF**).

The small signal parameters are the most important to understand, as they describe the transistor's behavior at audio and RF frequencies, and used in the circuit design equations. These parameters vary greatly from one transistor type to another, such that making assumptions (as we did with DC HFE =~100) can be risky. The data sheets must be used. The small-signal characteristics for **Ft** and **hfe**, from the data sheets, are shown in **Table 3**

Table 3 – SMALL SIGNAL CHARACTERISTICS – Part 1

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
Gain Bandwidth Prod.	Ft (MHz).	250	300	300	250	300
Small Signal Current Gain, hfe						
Ic=1.0 mA, Vce=10v†	hfe Min.	50	50	100	40	100
	hfe Max.	300	300	400	500	400
Estimated	hfe Typ.	150	150	200	225	200
Ic= 10 mA, Vce=10v†	HFE Min.	75	75	—	—	—
	HFE Max.	375	375	—	—	—

† Measured at 1 KHz

Gain Bandwidth Product, or **Ft**, is defined as the frequency at which the AC current gain, hfe, equals 1 (0dB). See **Fig. 3** (next page). This is the maximum frequency the device produces gain as an amplifier or oscillator.

On RF transistor data sheets, Ft is not always given. Instead, the **power gain, Gp** (or **Gpe** for common emitter power gain) is tested at a specific frequency. Ft can be derived from this information as shown in **Table 4**. Equations *x* and *Gp(mag)* convert the power gain, in dB, to unitless magnitude, as is hfe.

Table 4 – Calculating Ft from Gpe

$$x = \frac{Gp(dB)}{10} \qquad Gp(mag) = 10^{x}$$

$$Ft = f\sqrt{Gp(mag)}$$

Example:
The data sheet for the 2N5179 lists Gpe=15dB at 200MHz. Determine Ft.

$$x = \frac{15dB}{10} = \mathbf{1.5} \qquad Gp(mag) = 10^{1.5} = \mathbf{32}$$

$$Ft = 200MHz\sqrt{32} = \mathbf{1130\ MHz}$$

hfe is the **ac small-signal current gain**, and dependent on both frequency and the collector current. Hfe is also known as the *ac beta*. Ft and hfe work together to define the overall AC gain of the transistor at a specific frequency, as illustrated in **Fig. 3**.

hfeo is the low-frequency hfe, often very close to the DC HFE. The values for hfe shown in the data sheets are normally measured at 1KHz and Ic=1mA (sometimes @10mA). Hfeo is fairly constant from the audio frequencies to about 300 KHz.

Beta cut-off frequency, f , is the "3db point" of hfe, where hfe= 0.707hfeo, or f =Ft/hfeo. F is seldom listed on the data sheets.

hfe drops fairly linearly from f to Ft at 6dB/octave.

F , and the hfe vs. frequency plots, are seldom shown in the data books. ***This is why learning to interpret the data sheets is important to determine the actual gain (hfe) a transistor will provide at a specific frequency.***

Design Example: Constructing an Hfe vs. Frequency Plot
Let's figure out what hfe will be for a 2N2222 on the 40M band, using both graphical and equational methods. It's really easy.

From **Table 3**, hfe=50 (min) to 300 (max). Let's pick hfe=150 as the average. Since hfe is measured at 1KHz, this is also **hfeo**. Draw a line on a chart to represent hfeo=150 (line #1, **Fig. 4**).

Calculate f and hfe @f as follows: (Ft=250MHz, 2N2222)

f = Ft/hfeo = 250MHz 150 = 1.7 MHz

hfe@f = .707hfeo = 0.707 x 150 = 106

Draw a dot at hfe@f on the chart (hfe=106 @ 1.7 MHz)

Or ... calculate hfe at the desired frequency, fo, such as 7MHz

hfe@fo = Ft/fo = 250MHz 7MHz = 36

Draw a line between f (or fo) and Ft (line #2, **Fig. 4**) to complete the hfe vs. frequency plot of the 2N2222 at Ic=1mA.

Therefore, at 7 MHz

ac gain is hfe = 36

How much signal gain will the 2N2222 provide at 144 MHz?

hfe = Ft/fo = 250MHz 144MHz = 1.7, or almost unity!

This is why general purpose transistors (Ft <400MHz) are not used at VHF for lack of useful gain above ~50 MHz.

Hfe vs. Ic. Hfe is also a function of Ic as shown in **Fig. 5**. This data sheet chart is used to adjust hfe at Ic other than 1mA, where hfe is measured. For designing battery powered circuits, Ic=1mA is recommended. Firstly, data sheet values can be used directly, saving additional calculations, since most parameters are listed for Ic=1mA. Secondly, these transistors have ample gains at Ic=1mA or less. The additional gain at a higher Ic may not justify

Fig. 3 – Common Emitter AC current gain vs. Frequency

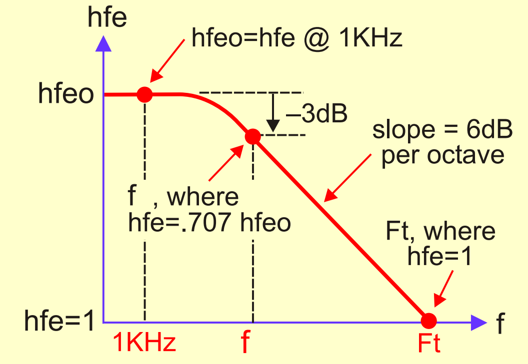
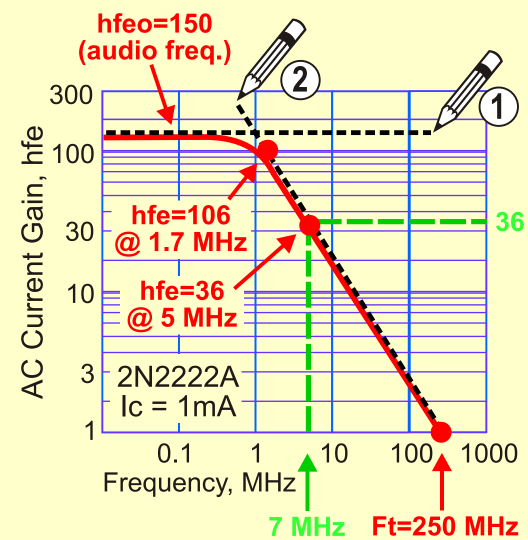


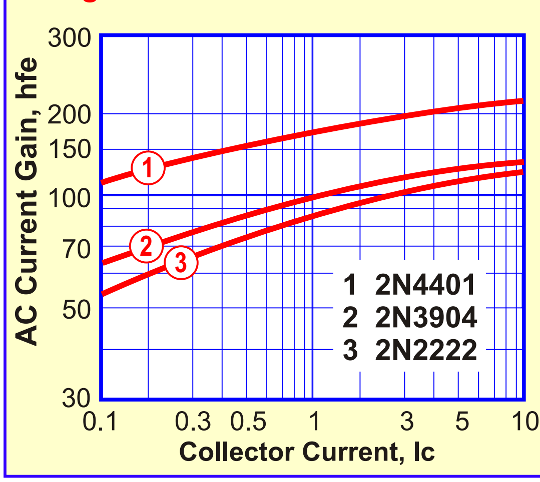
Fig. 4 – Constructing an hfe gain plot for the 2N2222 (Common Emitter)



For gain at any frequency, f < fo < Ft

$$hfe = \frac{Ft}{fo} \qquad \text{Gain(dB)} = 10\log(hfe)$$

Fig. 5 – Hfe vs. Collector Current



the increase in battery drain. I.e., two amplifiers at Ic=1mA will yield far more gain than one amplifier at Ic=2mA.

Table 6 shows hfe at different frequencies for the 2N2222.

Table 5 lists the remaining small-signal characteristics.

Table 5 – SMALL SIGNAL CHARACTERISTICS – Part 2

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
Input capacitance ‡	Cibo (max)	30pF	25pF	8pF	30pF	8pF
Output capacitance ‡	Cobo (max)	8pF	8pF	4pF	7pF	4pF
Input Impedance, typ. †	hie (min)	2K	2K	1K	1K	1K
	hie (max)	8K	8K	10K	15K	10K
Output Admittance †	hoe (min)	5*	5*	1*	1*	1*
	hoe (max)	35*	35*	40*	30*	40*
Noise Figure †	NF (max)	4dB	4dB	5dB	4.5dB	4dB

† Measured at 1 KHz ‡ Measured at 1 MHz * mhos

Input impedance, hie, is the resistive element of the base-emitter junction, and varies with Ic. It is used for input impedance calculations, and not particularly useful in itself without considering Cibo.

Input capacitance, Cibo, is the capacitance across the base-emitter junction. For the 2N2222, Cibo(max)=30pF. The reactance (Xc) of Cibo is in parallel with hie (Xc||hie) – causing the equivalent input impedance, Zin, to be frequency dependent as shown in **Table 6**. As can be seen, Xc(Cibo) dictates the input impedance of the transistor, *not hie*. Cibo is thus important in estimating Zin at any given frequency. In selecting a transistor for RF, the smaller the value of Cibo, the better. In this case, the input *impedance* is called Zin, since it includes the frequency dependent *reactance* components.

Input resistance, Rin, for the common-emitter transistor, can also be estimated using hfe and emitter current, Ie, as follows:

Rin = re(hfe+1)   where, re = 26   Ie(mA) (Ie   Ic)

The results of Rin from the above are also shown in **Table 6** for comparison. This method is generally preferred since hfe and Ie are known with greater accuracy than is hie and Cibo. In this case, the input *impedance* is called Rin, since it only includes resistive components (no *reactance* components).

The differences between the two methods, while close, demonstrates the difficulty in determining with certainty the input impedance of a transistor.

Output Admittance, hoe, represents the output resistance of the transistor by taking the reciprocal of the admittance. For example, at hoe(typ)=10umhos, Rout = 1/hoe = 1/10umhos = 100K . Like hie, hoe is not particularly useful by itself.

Output Resistance, Ro, is approximately the parallel equivalent of hoe and the collector load resistance, Rc, or Ro = Rc||hoe. See **Fig. 6**. Since Rc tends to be in the 1–5K range, and hoe 20–100K , Rc will dominate the output resistance of the transistor. As a result, output impedance is usually estimated by: Zo   Rc. Note that the output impedance is set primarily by circuit values (Rc), and not by the transistor's small-signal parameters.

Table 6 – 2N2222 Input Impedances

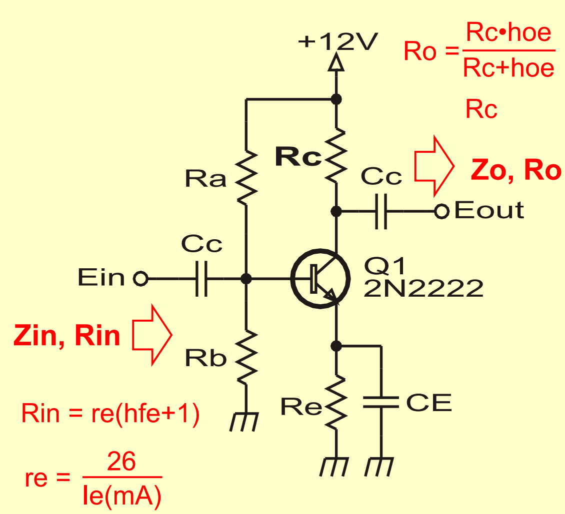
based on hfeo=150 — based on hfe and re — based on Xc(Cibo) || hie

Freq	hfe	Rin	Xc(Cibo)	Zin
3.5	71	1872	1516	1150
7.0	36	962	758	658
10.1	25	676	525	475
14.0	18	494	379	352
21.0	12	312	253	241
28.0	9	234	190	183
50.0	5	130	106	104
144	2	52	37	36

Rin=re(hfe+1)
where,
re=26/Ie(mA)
=26 @1mA

Zin(eq) = Xc||hie
where,
Cibo = 30pF
hie = 5K

Fig. 6 – Input/Output Impedances
basic amplifier configuration



Cobo is the **output capacitance**, and is in parallel with the output resistance. However, Cobo is <10pF in most general purpose NPN transistors and has little effect at HF. This parameter is important in RF transistors operating in the VHF/UHF spectrum, where the shunting effect becomes a significant component of the output impedance. Obviously, the lower the value of Cobo, the better.

Noise Figure, NF, is defined as the ratio of the input to the output noise, neither of which is easily measurable by the amateur. The transistor will add noise, then be amplified by the hfe of the device just as the signal is, forming signal plus noise output, or S+N. The excess in the S+N to signal power is due to the noise figure (NF) of the device.

For the QRPer, the NF of the transistor is not highly important on HF. See **Table 7**. Select a transistor with a low NF for the audio stage(s), however, as this is where it will be the most evident.

Transconductance, gm, is another parameter provided on some data sheets. If not provided, gm can be estimated by: gm = .038 x Ie(mA).

Table 7 – HF vs VHF Noise Figures

At HF – antenna and atmospheric noise is in the 20–30dB range, far exceeding the 10-12dB NF of a typical HF receiver. In other words, more noise is introduced to the receiver by the antenna and band conditions than the NF of the stages can introduce. For HF receiver applications, a NF of 4-6dB per transistor is sufficient. This is not the case at VHF.

At VHF/UHF – antenna and atmospheric noise is very low, often less than 10dB of noise power, making the overall system noise a function of the receiver, and the NF of the individual stages. At VHF/UHF, the NF of the transistors becomes very important, with transistors being selected with NF's in the 1.5dB to 2dB range not uncommon.

4. SWITCHING CHARACTERISTICS

The Switching Characteristics define the operating limits of the transistor when used in pulsed, digital logic, or switching applications. QRP switching circuits include T-R switching, CW keying and band switching circuits using transistors. These are really large-signal characteristics, since the transistor is being driven from cut-off to saturation in most switching applications.

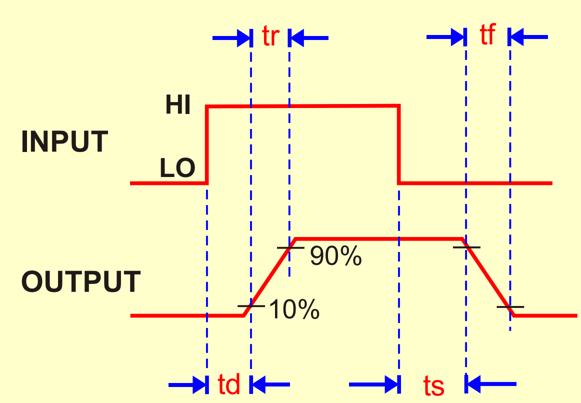
Table 8 – SWITCHING CHARACTERISTICS

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
Delay time	td	10ns	10ns	35ns	15ns	35ns
Rise time	tr	25ns	25ns	35ns	20ns	35ns
Storage time	ts	225ns	225ns	200ns	225ns	200ns
Fall time	tf	60ns	60ns	50ns	30ns	50ns

Fig. 7 illustrates the switching characteristics terms:
td, delay time is the time from the input L–H transition until the output begins to respond.
tr, rise time is the time it takes the output to go from 10% to 90% output voltage.
ts, storage time is the time from the input H–L transition until the output responds. This is usually the longest delay.
tf, fall time is the time it takes the output to go from 90% to 10% output voltage.

These switching times, in the tens of nanoseconds, are thousands of times faster than the requirements for QRP applications, and seldom a design criteria when selecting a transistor. It is presented here for completeness only.

Fig. 7 – Switching Characteristics



This tutorial should allow one to interpret the transistor data sheets, whether the complete data sheets from the manufacturer, or the abbreviated listings, such as found in the NTE Cross-Reference or in the ARRL Handbook. Many manufacturer's provide complete data sheets online. Understanding transistor specifications is essential in designing your own circuits, or identifying those "ham fest special" transistors and their suitability for your next project. Biasing transistors using these specs will be presented in a future *Handyman's* tutorial.

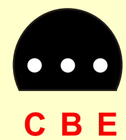
Paul Harden, NA5N

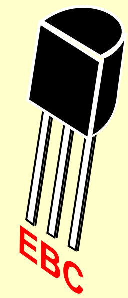
The Handyman's Guide to – UNDERSTANDING TRANSISTOR DATA SHEETS & SPECIFICATIONS

The QRPer's Favorite GENERAL PURPOSE NPN TRANSISTORS

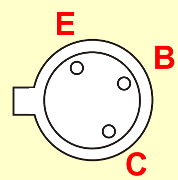
2N2222
2N3904
2N4401
MPS2222
MPS3904

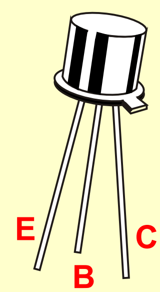
TO–92
Plastic Encapsulated Transistor





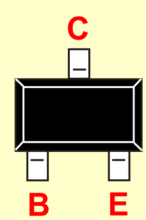
TO–18
Metal Can Transistor





SOT-23
Surface Mount Transistor

MMBT2222LT1
MMBT3904LT1
MMBT4401LT1



Introduction

The most common bipolar junction transistors (BJT) used by hobbyists and QRPers are the ***2N2222****,* ***2N3904*** *and* ***2N4401****. These NPN transistors have similar characteristics, and perform well at HF frequencies.*

This tutorial explains how to "read" the data sheets on these devices and understand the specifications – which will enable you to interpret data sheets for other devices as well.

The manufacturer's data sheets contains information in the following general categories:

1. Maximum (Breakdown) Ratings
2. "On" Characteristics
3. Small Signal Characteristics
4. Switching Characteristics

1. Maximum (Breakdown) Ratings

The maximum ratings are provided to ensure that the voltages and currents applied do not damage or cause excessive heating to the device. The maximum ratings for the 2N2222, 2N3904 and 2N4401are shown in **Table 1**. The voltages, currents and power dissipation listed should *not be exceeded* to prevent damage to the device.

V_{CEO} is the maximum **collector-emitter voltage** and **V_{CBO}** is the maximum **collector-base voltage**. Fortunately, these breakdown voltages are well above the typical 12v used in most QRP applications.

This is not the case with **V_{EBO},** the **maximum emitter-base voltage**, typically 5–6v. If exceeded, this can cause a physical breakdown of the base junction, destroying the

Table 1 – MAXIMUM (BREAKDOWN) RATINGS

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
Collector–Emitter	V_{CEO}	30v	40v	40v	40v	40v
Collector–Base	V_{CBO}	60v	75v	60v	60v	60v
Emitter–Base	V_{EBO}	5v	6v	6v	6v	6v
Max. Coll. Current	I_C	600mA	600mA	200mA	600mA	200mA
Power dissipation	Pd	625mW	625mW	625mW	625mW	225mW

transistor. In a circuit, the biasing scheme sets the base-emitter voltage, VBE, to be safely below VEBO. However, in large-signal applications, VBE must include the DC base bias *and the peak voltage of the signal* to ensure VEBO will not be exceeded.

> **Rule of thumb for VEBO:** VEBO(max) or Vbe(max) for most general purpose BJTs is 5–6v – the *maximum* emitter-base voltage. Don't forget to include the peak voltage of the AC signal!

Collector Current, Ic(max), is the other maximum rating to be closely followed. Collector current exceeding Ic(max) can damage the transistor, due to excessive current through the device, initiating thermal runaway – destroying the collector-emitter junction. The destruction of a transistor in this manner is technically called *catastrophic substrate failure* for good reason!

> **Rule of thumb for Ic(max):** There isn't one! The only safe way to know the maximum Ic for a transistor is to consult the data sheets.

Most QRP circuits are usually biased for well below Ic(max). Vbe(max) and Ic(max) are generally a concern only in large-signal applications, such as RF drivers, PA stages, and some oscillator circuits.

Table 2 – DC "ON" CHARACTERISTICS

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
DC Current Gain, HFE						
Ic= 0.1mA, VCE=10v	HFE Min.	35	35	40	20	40
Ic=1.0 mA, VCE=10v	HFE Min.	50	50	70	40	70
	HFE Max.	150	150	200	—	200
Ic= 10 mA, VCE=10v	HFE Min.	75	75	100	80	100
	HFE Max.	225	250	300	—	300
Collector-Emitter Saturation Voltage, VCE(sat)						
Ic= 150mA, IB= 15mA	VCE(sat)	0.4vdc	0.3vdc	0.3vdc†	0.4vdc	0.2vdc†
Base-Emitter Saturation Voltage, VBE(sat)						
Ic= 150mA, IB= 15mA	VBE(sat)	1.3vdc	1.2vdc	0.85vdc	0.95vdc	.85vdc†

† Ic=50mA, IB=5mA on 2N3904

2. ON CHARACTERISTICS

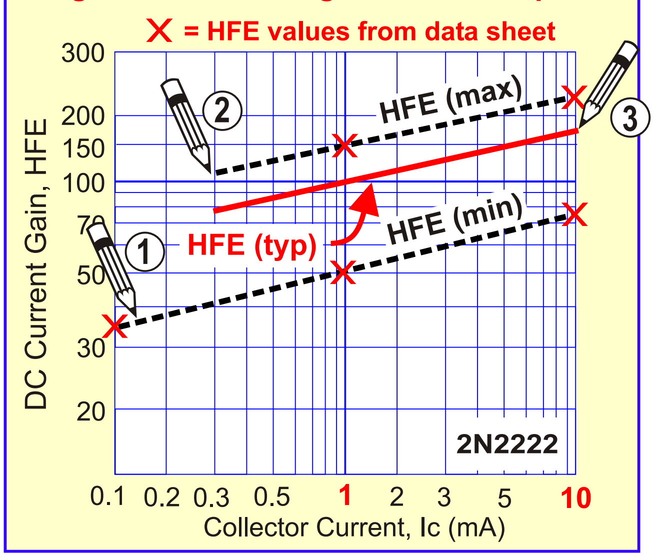
These specifications define the DC performance of the device while it is forward biased (Vbe ≥0.7v), causing collector current to flow, or "on." The DC Characteristics in **Table 2** are not absolute design values, but rather *test values* as measured by the manufacturer. This is why the data is listed with the test conditions, such as "Ic=1mA, VCE=10v."

> **Rule of thumb for HFE:**
> Conventions used in electronic literature:
>
> **HFE** or **hFE** (upper case letters) is the ***DC Current Gain***
> **Hfe** or **hfe** (lower case) is the ***AC current gain***

HFE is the *measured* **DC current gain** of the transistor (see *Rule of thumb for HFE*). It is used for biasing the device in the linear region – primarily class A. Most data sheets provide HFE at two different collector currents, usually 1 and 10mA. Since most QRP circuits are biased for Ic ≤5mA (to conserve battery drain), HFE at Ic=1mA is typically used.

HFE also varies from transistor–to–transistor. This is why the data sheets list both HFE (min) and HFE (max). The manufacturer tested a large batch of 2N2222s and determined that hfe ranged from 50 (HFE **min**) to 150 (HFE **max**) at Ic=1mA, as shown on the data sheets (**Table 2**). Statistically, most transistors will fall between 50 and 150, or about HFE=100. This is why most design guides will recommend using a value of HFE=100 for bias calculations. Since the 2N3904 has a higher DC current gain, often HFE=150 is recommended for that device.

Fig. 1 – Constructing an HFE vs. Ic plot



HFE min. and max, at Ic=1 and 10mA, can be plotted on a logarithmic graph (lines 1 and 2 on **Fig. 1**). The average

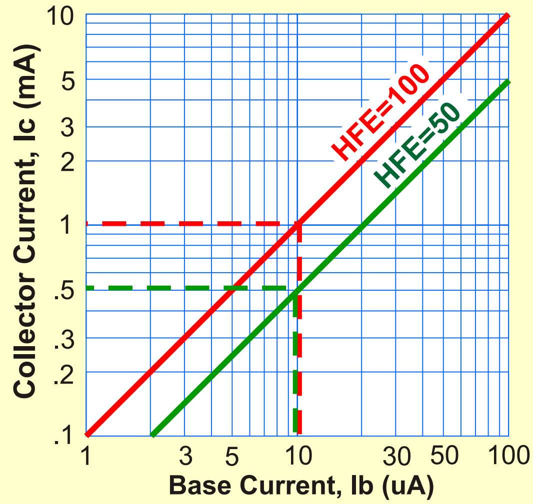
value, HFE typ., can then be drawn (line 3, **Fig. 1**). This gives you HFE (typ) for various collector currents.

The value used for HFE is not critical. Using HFE=100, or even the conservative value of 50, will work 99% of the time. Therefore, one scarcely needs the data sheets for the DC characteristics, as the typical HFE = 100 at Ic=1mA is valid for most general purpose NPN transistors. **Fig. 2** shows **Ib vs. Ic** for HFE at 50 and 100.

Saturation voltages, VCE(sat) and **VBE(sat)**, defines the transistor behavior *outside* the linear operating region, that is, in the saturated region. This is of interest when operating the transistor as a saturated switch. The keying transistor in a transmitter, forming the +12v transmit voltage on key–down, is an example of a saturated switch.

Rule of thumb for HFE:
Most general purpose NPN transistors have a DC HFE = 100 (typ) and thus used in most biasing equations for DC and low frequencies.

Fig. 2 – Ic vs. Ib defines HFE



At Ib=10uA, Ic=0.5mA @ HFE=50
At Ib=10uA, Ic=1.0mA @ HFE=100

3. SMALL SIGNAL CHARACTERISTICS

The small-signal characteristics describe the AC performance of the device. There is no standardized industry definition of small-signal (vs. large-signal), but is generally defined where the *AC signal* is small compared to the DC bias voltage. That is, the signal levels are well within the linear operating region of the transistor.

The small signal characteristics include:

1) gain bandwidth product (**Ft**)
2) the AC current gain (**hfe**)
3) input and output impedances (**hie** and **hoe**)
4) input and output capacitances (**Cibo** and **Cobo**)
5) the noise figure (**NF**).

Table 3 – SMALL SIGNAL CHARACTERISTICS – Part 1

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
Gain Bandwidth Prod.	Ft (MHz).	250	300	300	250	300
Small Signal Current Gain, hfe						
Ic=1.0 mA, Vce=10v†	hfe Min.	50	50	100	40	100
	hfe Max.	300	300	400	500	400
Estimated	hfe Typ.	150	150	200	225	200
Ic= 10 mA, Vce=10v†	HFE Min.	75	75	—	—	—
	HFE Max.	375	375	—	—	—

† Measured at 1 KHz

The small signal parameters are the most important to understand, as they describe the transistor's behavior at audio and RF frequencies, and used in the circuit design equations. These parameters vary greatly from one transistor type to another, such that making assumptions (as we did with DC HFE =~100) can be risky. The data sheets must be used. The small-signal characteristics for **Ft** and **hfe**, from the data sheets, are shown in **Table 3**

Gain Bandwidth Product, or **Ft**, is defined as the frequency at which the AC current gain, hfe, equals 1 (0dB). See **Fig. 3** (next page). This is the maximum frequency the device produces gain as an amplifier or oscillator.

On RF transistor data sheets, Ft is not always given. Instead, the **power gain, Gp** (or **Gpe** for common emitter power gain) is tested at a specific frequency. Ft can be derived from this information as shown in **Table 4**. Equations *x* and *Gp(mag)* convert the power gain, in dB, to unitless magnitude, as is hfe.

Table 4 – Calculating Ft from Gpe

$$x = \frac{Gp(dB)}{10} \qquad Gp(mag) = 10^{x}$$

$$Ft = f\sqrt{Gp(mag)}$$

Example:
The data sheet for the 2N5179 lists Gpe=15dB at 200MHz. Determine Ft.

$$x = \frac{15dB}{10} = \mathbf{1.5} \qquad Gp(mag) = 10^{1.5} = \mathbf{32}$$

$$Ft = 200MHz\sqrt{32} = \mathbf{1130\ MHz}$$

hfe is the **ac small-signal current gain**, and dependent on both frequency and the collector current. Hfe is also known as the *ac beta*. Ft and hfe work together to define the overall AC gain of the transistor at a specific frequency, as illustrated in **Fig. 3**.

hfeo is the low-frequency hfe, often very close to the DC HFE. The values for hfe shown in the data sheets are normally measured at 1KHz and Ic=1mA (sometimes @10mA). Hfeo is fairly constant from the audio frequencies to about 300 KHz.

Beta cut-off frequency, f, is the "3db point" of hfe, where hfe= 0.707hfeo, or f =Ft/hfeo. F is seldom listed on the data sheets.

hfe drops fairly linearly from f to Ft at 6dB/octave.

F , and the hfe vs. frequency plots, are seldom shown in the data books. ***This is why learning to interpret the data sheets is important to determine the actual gain (hfe) a transistor will provide at a specific frequency.***

Design Example: Constructing an Hfe vs. Frequency Plot

Let's figure out what hfe will be for a 2N2222 on the 40M band, using both graphical and equational methods. It's really easy.

From **Table 3**, hfe=50 (min) to 300 (max). Let's pick hfe=150 as the average. Since hfe is measured at 1KHz, this is also **hfeo**. Draw a line on a chart to represent hfeo=150 (line #1, **Fig. 4**).

Calculate f and hfe @f as follows: (Ft=250MHz, 2N2222)

f = Ft/hfeo = 250MHz 150 = 1.7 MHz

hfe@f = .707hfeo = 0.707 x 150 = 106

Draw a dot at hfe@f on the chart (hfe=106 @ 1.7 MHz)

Or ... calculate hfe at the desired frequency, fo, such as 7MHz

hfe@fo = Ft/fo = 250MHz 7MHz = 36

Draw a line between f (or fo) and Ft (line #2, **Fig. 4**) to complete the hfe vs. frequency plot of the 2N2222 at Ic=1mA.

Therefore, at 7 MHz

ac gain is hfe = 36

How much signal gain will the 2N2222 provide at 144 MHz?

hfe = Ft/fo = 250MHz 144MHz = 1.7, or almost unity!

This is why general purpose transistors (Ft <400MHz) are not used at VHF for lack of useful gain above ~50 MHz.

Hfe vs. Ic. Hfe is also a function of Ic as shown in **Fig. 5**. This data sheet chart is used to adjust hfe at Ic other than 1mA, where hfe is measured. For designing battery powered circuits, Ic=1mA is recommended. Firstly, data sheet values can be used directly, saving additional calculations, since most parameters are listed for Ic=1mA. Secondly, these transistors have ample gains at Ic=1mA or less. The additional gain at a higher Ic may not justify

Fig. 3 – Common Emitter AC current gain vs. Frequency

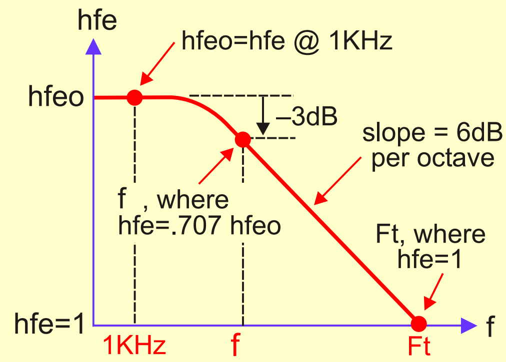
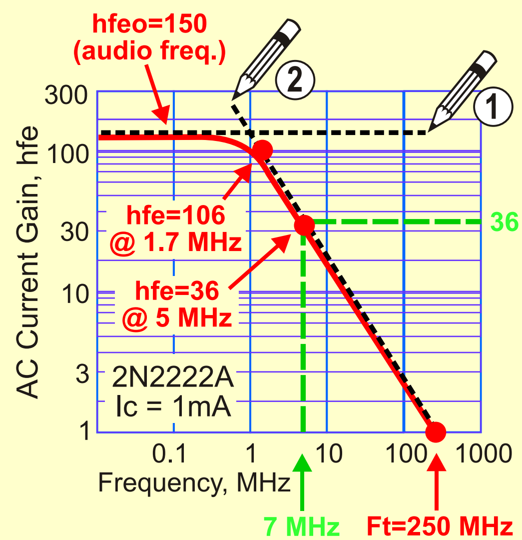


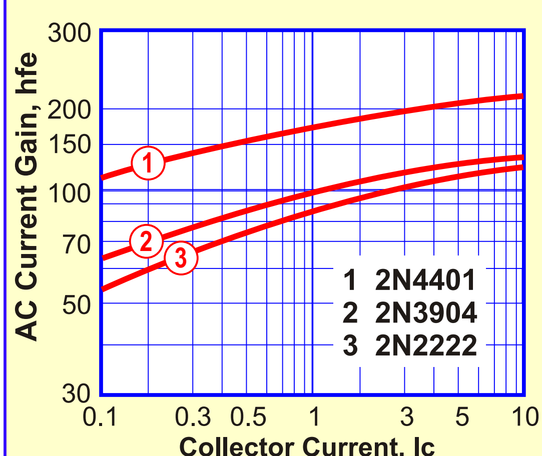
Fig. 4 – Constructing an hfe gain plot for the 2N2222 (Common Emitter)



For gain at any frequency, f < fo < Ft

$$hfe = \frac{Ft}{fo} \qquad Gain(dB) = 10\log(hfe)$$

Fig. 5 – Hfe vs. Collector Current



the increase in battery drain. I.e., two amplifiers at Ic=1mA will yield far more gain than one amplifier at Ic=2mA.

Table 6 shows hfe at different frequencies for the 2N2222.

Table 5 lists the remaining small-signal characteristics.

Table 5 – SMALL SIGNAL CHARACTERISTICS – Part 2

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
Input capacitance ‡	Cibo (max)	30pF	25pF	8pF	30pF	8pF
Output capacitance ‡	Cobo (max)	8pF	8pF	4pF	7pF	4pF
Input Impedance, typ. †	hie (min)	2K	2K	1K	1K	1K
	hie (max)	8K	8K	10K	15K	10K
Output Admittance †	hoe (min)	5*	5*	1*	1*	1*
	hoe (max)	35*	35*	40*	30*	40*
Noise Figure †	NF (max)	4dB	4dB	5dB	4.5dB	4dB

† Measured at 1 KHz ‡ Measured at 1 MHz * mhos

Input impedance, hie, is the resistive element of the base-emitter junction, and varies with Ic. It is used for input impedance calculations, and not particularly useful in itself without considering Cibo.

Input capacitance, Cibo, is the capacitance across the base-emitter junction. For the 2N2222, Cibo(max)=30pF. The reactance (Xc) of Cibo is in parallel with hie (Xc||hie) – causing the equivalent input impedance, Zin, to be frequency dependent as shown in **Table 6**. As can be seen, Xc(Cibo) dictates the input impedance of the transistor, *not hie*. Cibo is thus important in estimating Zin at any given frequency. In selecting a transistor for RF, the smaller the value of Cibo, the better. In this case, the input *impedance* is called Zin, since it includes the frequency dependent *reactance* components.

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Rin = re(hfe+1) where, re = 26 Ie(mA) (Ie Ic)

The results of Rin from the above are also shown in **Table 6** for comparison. This method is generally preferred since hfe and Ie are known with greater accuracy than is hie and Cibo. In this case, the input *impedance* is called Rin, since it only includes resistive components (no *reactance* components).

The differences between the two methods, while close, demonstrates the difficulty in determining with certainty the input impedance of a transistor.

Output Admittance, hoe, represents the output resistance of the transistor by taking the reciprocal of the admittance. For example, at hoe(typ)=10umhos, Rout = 1/hoe = 1/10umhos = 100K . Like hie, hoe is not particularly useful by itself.

Output Resistance, Ro, is approximately the parallel equivalent of hoe and the collector load resistance, Rc, or Ro = Rc||hoe. See **Fig. 6**. Since Rc tends to be in the 1–5K range, and hoe 20–100K , Rc will dominate the output resistance of the transistor. As a result, output impedance is usually estimated by: Zo Rc. Note that the output impedance is set primarily by circuit values (Rc), and not by the transistor's small-signal parameters.

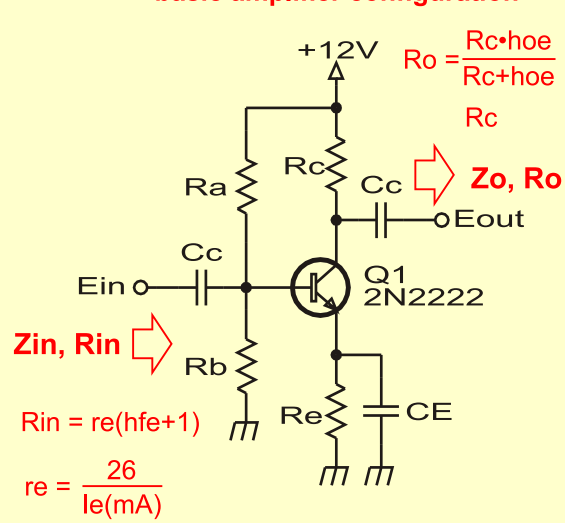
Table 6 – 2N2222 Input Impedances

Freq	hfe (based on hfeo=150)	Rin (based on hfe and re)	Xc(Cibo)	Zin (based on Xc(Cibo) || hie)
3.5	71	1872	1516	1150
7.0	36	962	758	658
10.1	25	676	525	475
14.0	18	494	379	352
21.0	12	312	253	241
28.0	9	234	190	183
50.0	5	130	106	104
144	2	52	37	36

Rin=re(hfe+1)
where,
re=26/Ie(mA)
=26 @1mA

Zin(eq) = Xc||hie
where,
Cibo = 30pF
hie = 5K

Fig. 6 – Input/Output Impedances
basic amplifier configuration



Cobo is the **output capacitance**, and is in parallel with the output resistance. However, Cobo is <10pF in most general purpose NPN transistors and has little effect at HF. This parameter is important in RF transistors operating in the VHF/UHF spectrum, where the shunting effect becomes a significant component of the output impedance. Obviously, the lower the value of Cobo, the better.

Noise Figure, NF, is defined as the ratio of the input to the output noise, neither of which is easily measurable by the amateur. The transistor will add noise, then be amplified by the hfe of the device just as the signal is, forming signal plus noise output, or S+N. The excess in the S+N to signal power is due to the noise figure (NF) of the device.

For the QRPer, the NF of the transistor is not highly important on HF. See **Table 7**. Select a transistor with a low NF for the audio stage(s), however, as this is where it will be the most evident.

Transconductance, gm, is another parameter provided on some data sheets. If not provided, gm can be estimated by: gm = .038 x Ie(mA).

Table 7 – HF vs VHF Noise Figures

At HF – antenna and atmospheric noise is in the 20–30dB range, far exceeding the 10-12dB NF of a typical HF receiver. In other words, more noise is introduced to the receiver by the antenna and band conditions than the NF of the stages can introduce. For HF receiver applications, a NF of 4-6dB per transistor is sufficient. This is not the case at VHF.

At VHF/UHF – antenna and atmospheric noise is very low, often less than 10dB of noise power, making the overall system noise a function of the receiver, and the NF of the individual stages. At VHF/UHF, the NF of the transistors becomes very important, with transistors being selected with NF's in the 1.5dB to 2dB range not uncommon.

4. SWITCHING CHARACTERISTICS

The Switching Characteristics define the operating limits of the transistor when used in pulsed, digital logic, or switching applications. QRP switching circuits include T-R switching, CW keying and band switching circuits using transistors. These are really large-signal characteristics, since the transistor is being driven from cut-off to saturation in most switching applications.

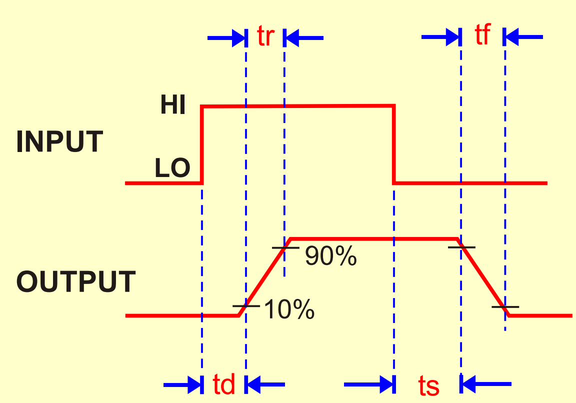
Table 8 – SWITCHING CHARACTERISTICS

		2N 2222	2N 2222A	2N 3904	2N 4401	MMBT 3904
Delay time	td	10ns	10ns	35ns	15ns	35ns
Rise time	tr	25ns	25ns	35ns	20ns	35ns
Storage time	ts	225ns	225ns	200ns	225ns	200ns
Fall time	tf	60ns	60ns	50ns	30ns	50ns

Fig. 7 illustrates the switching characteristics terms:
td, delay time is the time from the input L–H transition until the output begins to respond.
tr, rise time is the time it takes the output to go from 10% to 90% output voltage.
ts, storage time is the time from the input H–L transition until the output responds. This is usually the longest delay.
tf, fall time is the time it takes the output to go from 90% to 10% output voltage.

These switching times, in the tens of nanoseconds, are thousands of times faster than the requirements for QRP applications, and seldom a design criteria when selecting a transistor. It is presented here for completeness only.

Fig. 7 – Switching Characteristics



This tutorial should allow one to interpret the transistor data sheets, whether the complete data sheets from the manufacturer, or the abbreviated listings, such as found in the NTE Cross-Reference or in the ARRL Handbook. Many manufacturer's provide complete data sheets online. Understanding transistor specifications is essential in designing your own circuits, or identifying those "ham fest special" transistors and their suitability for your next project. Biasing transistors using these specs will be presented in a future *Handyman's* tutorial.

BUTTERNUT Manufacturing Co.

Instructions

Model HF6V-X

PLEASE READ ALL INSTRUCTIONS THOROUGHLY BEFORE PROCEEDING TO ASSEMBLY. DURING ASSEMBLY AND INSTALLATION TAKE EXTREME CARE TO AVOID CONTACTING POWER LINES WITH ANY PART OF THE ANTENNA OR OTHER CONDUCTORS.

DO NOT INSTALL THE ANTENNA IN ANY PLACE WHERE ANY PART OF IT CAN COME INTO CONTACT WITH POWER LINES IN THE EVENT OF STRUCTURAL FAILURE OF ANY PART OF THE INSTALLATION OR IN THE COURSE OF NORMAL FLEXING AFTER INSTALLATION, FOR SUCH CONTACT CAN RESULT IN DAMAGE TO PROPERTY, BODILY INJURY OR DEATH!

IN NO CASE SHOULD THE ANTENNA BE INSTALLED IN ANY PLACE WHERE STRUCTURAL FAILURE OF ANY PART OF THE ANTENNA OR ITS SUPPORTING SYSTEM CAN ENDANGER PERSONS OR PROPERTY.

CAUTION! A GROUNDED ANTENNA WILL BE AT DC GROUND POTENTIAL! TO AVOID DANGER OF SHOCK CONNECT ALL STATION EQUIPMENT TO A GOOD EARTH GROUND. IT IS ALSO RECOMMENDED THAT ALL STATION EQUIPMENT BE DISCONNECTED FROM THE POWER MAINS BEFORE CONNECTING THE FEEDLINE TO THE ANTENNA. PLEASE CONSULT THE A.R.R.L. HANDBOOK OR OTHER REFERENCE MANUALS FOR ADDITIONAL SAFETY PROCEDURES WHEN WORKING WITH ELECTRICAL EQUIPMENT.

Tools required for assembly: flat blade screwdriver, pliers and a knife. A set of nut-drivers will be useful.

ASSEMBLY

TO ASSEMBLE AN HF9V-X, FOLLOW THESE INSTRUCTIONS, THEN INSTALL THE A-17-12 AND A6 ADAPTERS.

NOTE: A small packet of anti-seize/anti oxide compound will be found inside mounting post A. This compound should be applied lightly to each tubing joint and to the inside of all clamps that must make good electrical contact with the tubing sections.

Refer to the appropriate drawings and diagrams and proceed as follows:

1. Check to be sure that all parts are present (see parts pictorial page.)

2. Locate tube A w/insulator (A). This is one of two lengths of 2' x 1 1/8" tubing that has a glass-epoxy insulating rod attached to it at one end. Tube a w/insulator (A) can be recognized by the long machine screw passing through the tube and the insulator. Do not confuse it with the piece of the same size and length that has the short machine screw.

3. If the antenna is to be installed at ground level, plant tube A w/insulator (A) in a hole approximately 21" (55cm) deep so that the upper end of the glass-epoxy insulator rod is approximately 5", 12 cm above ground level. Pack earth tightly around the mounting post so that it will remain vertical. Concrete may be used in areas of high winds for greater strength, in which case the post may be twisted slightly during setting for easy removal later. The mounting post tube should be protected

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against corrosion if it is to be placed in concrete or damp, acidic or alkaline soil. Asphalt roofing compound, polyurethane varnish or any other sealant that protects against moisture may be used. No such protection is required for above-ground and most ground-level installations.

NOTE: hammering the mounting post into the earth may cause the insulator rod to splinter. If the post must be hammered into the earth, protect the end of the rod with a block of wood. If a permanent installation is not desired, a steel or other metallic tube having an inner diameter slightly larger than the outer diameter of tube A w/insulator (A) may be used, by inserting tube a w/insulator (A) into this outer tube for later removal. If the antenna is to be installed in an elevated position rather than at ground level, please refer to the note following Step 20 below, and to separate roof mounting kit/radial information. Use caution in handling the glass-epoxy insulators, for small splinters or flakes of this material may be present and cause irritation to sensitive skin. Above all, avoid rubbing the eyes after handling this material.

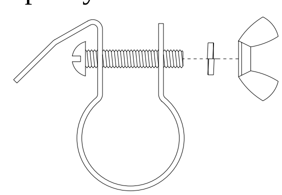
4. Prepare the coil Q base matching (Q) as shown in the pictorial drawing near the end of the instructions.

5. Locate tube B1 section (B1) the extension tube on the parts page. This tube is 28" long and has a greater outer diameter, 1 1/4" than any other tube. Slide the unslotted end of this tube over the insulator at the top of tube A w/insulator (A), line up the holes and fasten it securely in place with a #8 x 2" machine screw, lockwasher and hex nut.

6. Locate tube B2 w/insulator (B2). This is the other section of 2' x 1 1/8" tube, fastened to a glass-epoxy insulator by means of a short machine screw.

7. Locate tube (B3). This is a 3' x 1 1/8" tube. Slide the unslotted end over the glass-epoxy insulator of tube B2 w/insulator (B2), line up the holes and fasten securely by means of 1 1/2" machine screw, lockwasher and hex nut. The completed sub-assembly of tube B2 w/insulator (B2) + tube (B3) may now be removed to a more convenient place where dropped hardware can be more easily recovered during the attachment of the 80 and 40 meter coils and capacitors.

8. Locate coil assembly 80/40 meter (C) and slide the clamp at the outer end of the larger coil over the longer (upper) tube of the “B” sub-assembly, lowering the entire coil assembly until the middle clamp can be positioned around the glass-epoxy insulator rod. The middle clamp may have to be pulled open slightly to pass over the tubing and the bolt that goes through the upper tube and the insulator rod. Position the center coil clamp around the insulator rod so that the distance from the clamp to the end of either piece of tubing is approximately equal, and pass a #10 x 1" machine screw through the holes of the center coil clamp as shown in the drawing immediately below. The outer tab of this clamp may be bent back slightly to provide clearance for the bolt, and it may be bent back into place after final assembly. Fasten the center coil clamp firmly in place using a split lockwasher and a wing nut. Repeat the procedure for the two remaining coil clamps, tightening the wing nut only enough to hold the hardware in place. Coil adjustment will be made later.



9. Locate the 80-40 meter capacitors, installed on a flat strip with a large center hole. Install the longer capacitor bracket 80 meter (D1) on the larger capacitor, using a #10 x 3/8" machine screw and lockwasher, see pictorial. Install the (smaller) capacitor bracket 40 meter (D2) on the smaller capacitor, using a #6 x 1/4" machine screw and lockwasher. DO NOT OVER-TIGHTEN CAPACITOR MOUNTING SCREWS!

10. Line up the hole in the center of the capacitor strip with the threaded end of the long #10 machine screw protruding from the tab of the center coil clamp. Make sure that the capacitor bracket 80 meter (D1) runs alongside the larger, 80 meter coil of coil assembly 80/40 meter (C). Fasten the smaller center strip of capacitor assembly 80/40 meter (D) to the tab of the center coil clamp, using a flat washer, a split lockwasher and a #10 hex nut. Finally, fasten the tab end of the capacitor assembly firmly against the upper and lower tubes of “B” assembly by means of the two large non-adjustable

compression clamps. These clamps use a#8 x 1" machine screw, a split lockwasher and a hex nut. If a flat blade screwdriver is used to tighten the clamps do not grasp the work immediately opposite the blade in order to avoid injury if the blade slips.

11. Locate tubing sections tube E1 w/coupling (E1), tube (E2), tube (F), tube (G), tube (H), tube (I) and tube (J) as well as wire clamp 15M w/insulator (M) and wire clamp 15M w/insulator (N). Please note that as tubes are assembled the <u>unslotted</u> end of each tube will be pointing downward and the <u>slotted</u> end will be pointing upward. Slide wire clamp 15M w/insulator (M) over tube (G) and use the attached hardware to secure wire clamp 15M w/insulator (M) at the approximate center of the tube. Similarly, slide wire clamp 15M w/insulator (N) over tube (H) and tighten the hardware only enough to hold everything in place until final alignment of the 15 meter de-coupling stub.

IN THE FOLLOWING STEPS TUBES “E1" THROUGH “J” WILL BE FASTENED TOGETHER BY MEANS OF #8 HARDWARE, BOLT, SPLIT LOCKWASHER AND HEX NUT. AN 11/32" NUT DRIVER WILL BE USEFUL BUT NOT NECESSARY, IF A FLAT BLADE SCREWDRIVER IS USED DO NOT HOLD THE WORK IMMEDIATELY OPPOSITE THE BLADE IN ORDER TO AVOID INJURY IF THE BLADE SLIPS.

12. Slide one end of tube (E2) over the short smaller diameter tube emerging from the upper end of tube E1 w/coupling (E1), try both ends for best fit, align the holes, and pass a #8 x 1¼" machine screw through both tubes. Place a split lockwasher and a hex nut on the threaded end of the bolt and tighten snugly.

13. Insert the unslotted end of tube (F) into the slotted end of tube (E2) and proceed as in step 12, using a #8 x 1¼" machine screw and hardware.

    Insert the unslotted end of tube (G) into the slotted end of tube (F) and proceed as in step 12.

14. Insert the unslotted end of tube (H) into the slotted end of tube (G) and proceed as before, using a #8 x 1" machine screw and hardware.

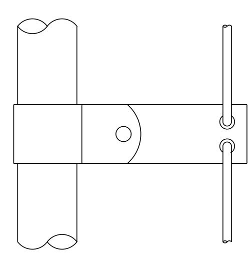
15. Proceed in the same way with the remaining tubes, using the remaining #8 hardware as needed. Note that a small adjustable hose clamp is provided for the slotted upper end of tube (I) to permit adjustment of tube (J).

16. Locate wire clamp 15M w/wire (L) and the attached length of stranded wire. Position the clamp around tube (I) so that its upper edge is approximately 8.5" (21.5cm) below the upper end of tube (I). Pass a #8 x 3/4" machine screw through the clamp holes and secure firmly with a split lockwasher and a hex nut.

17. Locate wire clamp 15M w/insulator (K) and position it around tube (E2), using a #8 x 1" machine screw, split lockwasher and a hex nut. The plastic insulator at the end of wire clamp 15M w/insulator (K) should point upward.

18. Measure from the rivet of wire clamp 15M w/wire (L) to a point that is 11' 3" (3.43m) along the stranded wire. Mark this point for future reference.

19. Pass the free end of the stranded wire from wire clamp 15M w/wire (L) downward through the small holes in wire clamp 15M w/insulator (M) and (N) as shown in the illustration to the right. wire clamp 15M w/insulator (M) and (N) may be turned on their tubes so that they line up with wire clamp 15M w/wire (L). Loop the end of the wire through the hole in the plastic insulator of wire clamp 15M w/insulator (K) and slide it along tube (F) until the mark on the wire appears at the small hole in the insulator. Wind the wire back on itself above the insulator to keep the excess out of the way. Do not cut off the excess wire.



ASSEMBLY

20. Line up wire clamp 15M w/insulator (K) with wire clamp 15M w/wire (L) and wire clamp 15M w/insulator (M) and (N). Position wire clamp 15M w/insulator (K) so that the wire is moderately taut but not so tight as to cause the upper tubing sections to bow. This completes assembly of tube E1 w/coupling (E1) through tube (J). These may be set aside for later installation atop (B) assembly.

NOTE: In the following steps the antenna will be assembled and raised to its full vertical height, after which the 30 meter tuning circuit will be installed. If the antenna is to be installed in an elevated position, rooftop, mast, tower etc., where it is unsafe or inconvenient to make in-place adjustments, the antenna may have to be installed in one piece, in which case it will probably be necessary to raise and lower it and its supporting structure a number of times to arrive at the "ideal" adjustment on all bands. If so, every precaution should be observed to avoid possible contact with power lines and to prevent structural failure that can cause injury to persons or property. DO NOT USE U-BOLTS TO ATTACH THE TUBE A W/INSULATOR (A) TO A MAST, TOWER OR VENT PIPE OR OTHER SUCH SUPPORT, FOR U-BOLTS WILL EVENTUALLY CUT INTO THE TUBING AND WEAKEN THE INSTALLATION. If, however, U-bolts must be used, place a larger diameter metal tube or other suitable protective material around the mounting post tube. Similar precautions should be observed when using TV-style towers with locking bolts. The Butternut Roof Mounting Kit (model RMK-II) includes a protective sleeve for the mounting post tube; this tube is also available separately as model MPS for non-permanent ground-level installations. And, always, AVOID POWER LINES!!

21. Take up the completed “B” assembly, both tubes, the 80/40 meter coils, capacitors and insert the 80 meter end, tube B2 w/insulator (B2) into the tube B1 section (B1) atop the tube A w/insulator (A).

    Slide the completed “B” assembly into the tube B1 section (B1) so that the distance between the bottom of tube B1 section (B1) and the upper end of tube B2 w/insulator (B2) is 48 inches, see pictorial. Place a pencil mark at the point where the tube B1 section (B1) overlaps tube B2 w/insulator (B2).

    The larger adjustable hose clamp may be placed over the upper slotted end of tube B1 section (B1) and tightened at this point, but that would mean that the tube E1 w/coupling (E1) through tube (J) assembly will have to be elevated and held with lower end some 7' above ground for insertion into the upper tube of “B” assembly.

    If one does not have the reach or if high winds are a problem during installation it will probably be easier to install the completed “B” assembly as part of the assembly to be raised, in which case the “B” through “J” assembly need be raised only 30" or so above ground.

    In either case, use a #8 x 1 1/2" machine screw, lockwasher and hex nut to attach tube E1 w/coupling (E1) to the upper tube of “B” assembly, tube (B3).

    An overall vertical length of 26' from the feedpoint on the tube B1 section (B1) to the tip of tube (J) can be used for most ground-level dimensions, and tube (J) can be adjusted as needed for the sake of 10 meter tuning. Alternatively, a distance of 23' 8" may be measured from the tip of tube (J) to your pencil mark on the lower tube of section B to arrive at a preliminary length setting.

22. Locate coil support tube 30 meter (O) and the coil/capacitor assembly 30 meter (P). Coil support tube 30 meter (O) is the short tube with a tubular plastic insulator at one end. Note that the upper end of coil/capacitor assembly 30 meter (P) is connected to a double clamp assembly that includes a ceramic capacitor. Place a #10 split lockwasher and a wing nut on the bolt through the lower single clamp attached to coil/capacitor assembly 30 meter (P) and tighten just enough to hold the hardware in place. Locate the coil support tube 30 meter L bracket (O1). Fasten this clamp to coil support tube 30 meter (O) through the hole in the bottom using a #8 x 3/4" bolt, a split lockwasher and a hex nut.

23. Pass the lower clamp of coil/capacitor assembly 30 meter (P) over the insulator end of coil support tube 30 meter (O) and slide the coil downward along the tube until the upper edge of the upper clamp is flush with the end of the plastic insulator. Position the upper clamp so that the entire upper

assembly points in the same direction as the "L"-shaped clamp at the bottom of coil support tube 30 meter (O). Tighten the upper clamp around the insulator and set the completed coil support tube 30 meter (O)/coil/capacitor assembly 30 meter (P) assembly aside.

24. From the middle of the center clamp of coil assembly 80/40 meter (C), measure <u>downward</u> to a point that is 13" (33cm) along the lower tube B2 w/insulator (B2). Mark this point and stretch the 80 meter, larger coil until the lower edge of the bottom clamp is even with the mark. Tighten the wing nut to secure the clamp at this point.

25. From the middle of the center clamp of coil assembly 80/40 meter (C), measure <u>upward</u> to a point 9 3/8" (24cm) along the upper tube (B3). Mark this point and stretch the 40 meter, smaller coil until the upper edge of the upper clamp is even with the mark. Tighten the wing nut to secure the clamp at this point.

26. Take up the assembled 30 meter unit, coil support tube 30 meter (O)/coil/capacitor assembly 30 meter (P) and position the remaining upper clamp of this unit around the tube (B3) so that the L-bracket clamp from the lower end of coil support tube 30 meter (O) is even with the fourth turn, counting from the top down on the 40 meter coil. Use a split lockwasher and a hex nut to tighten this clamp a slight amount.

27. Hook the L-bracket clamp from coil support tube 30 meter (O) around the fourth turn of the 40 meter coil and use small #8 hardware to tighten the clamp securely around the coil. Adjust the position of the 30 meter unit along tube (B3) to avoid distorting the 40 meter coil. Tighten securely.

28. From the upper edge of the upper coil clamp on the coil/capacitor assembly 30 meter (P)/coil support tube 30 meter (O) measure downward to a point 9 7/8" (25cm) along coil support tube 30 meter (O) and mark this point with a pencil. Stretch the 30 meter coil until the lower edge of the lower clamp is even with this mark. Tighten the wing nut to secure the clamp at this setting. This completes the preliminary adjustment of the 80, 40 and 30 meter coils. Refer to the pictorial page.

29. Install the coax 75 ohm matching line (R) on tube A w/insulator (A) and tube B1 section (B1) as shown in the pictorial. Simply place the lugs over the ends of the #8 bolts at this time. The center conductor connects to tube B1 section (B1), the braid to tube A w/insulator (A).

30. Place #8 flat washers over the lugs and install coil Q base matching (Q) as shown. Point 1 should go to section (B), point 2 to tube A w/insulator (A) and point 3 to any ground rod or other earth connection. Secure the connection to tube A w/insulator (A) and tube B1 section (B1) with flat washers, lockwashers and hex nuts. Radials or additional grounding may be attached to the connection on tube A w/insulator (A) with the remaining #8 hardware.

31. MAKE SURE THAT THE STATION EQUIPMENT IS CONNECTED TO A GOOD EARTH GROUND! DO NOT HANDLE ANY CABLE CONNECTED TO STATION EQUIPMENT WITHOUT FIRST DISCONNECTING THE EQUIPMENT FROM THE POWER MAINS. YOU COULD BE ELECTROCUTED!

32. Connect coax 75 ohm matching line (R) to any length of 50-53 ohm coaxial cable. A PL-258 "barrel" connector (S) is provided. A small roll of weatherproof sealing tape has been provided. This may be used to seal the outside of the RF connectors that join the coax 75 ohm matching line (R) to the transmission line.

CHECKOUT AND ADJUSTMENT

The dimensions and coil settings given above should produce reasonably low VSWR readings over the entire 10, 15, 20 and 30 meter bands and over at least 250 kHz of the 40 meter band. Bandwidth on 80/75 meters should be at least 30 kHz for VSWR of 2:1 or less, depending on the efficiency of the

ground system used, greater bandwidth being associated with lossy ground systems. It should be remembered that on those bands where the physical height of a vertical antenna is less than a quarter wavelength, the earth (or the resonant radial system in above-ground installations) will have a good deal to do with VSWR, antenna tuning, bandwidth, and overall performance.

Low VSWR by itself does not mean that a vertical antenna is operating efficiently, and if low VSWR is obtained with no more than the usual "quick and dirty" ground connection, it most likely means the opposite. In general, poor operation or improper tuning of vertical antennas can usually be traced to inadequate (or even reactive) ground systems or to other vertical conductors in the vicinity of the antenna. For these reasons it is suggested that the antenna be placed as much in the clear as possible and used with the best ground system that conditions permit. For a more complete discussion of the inter-relationships between vertical antenna efficiency, bandwidth, VSWR etc., a standard text such as the A.R.R.L. Antenna Book is recommended. Also review the material included at the end of these instructions.

For adjustment purposes a simple VSWR indicator may be used. More accurate measurements may be made at the antenna, i.e. at the junction of the 75 ohm matching line and the main transmission line, but the tuning conditions that exist at the transmitter will usually be of greater interest.

1. Determine the frequency at which VSWR is lowest on 80/75 meters. The coil settings given earlier should produce resonance and lowest VSWR at approximately 3700 kHz. To raise the frequency of resonance and lowest VSWR, simply loosen the wing nut on the lower coil clamp of the lower (80 meter) coil on section B and stretch the coil a bit more. To lower the frequency, compress this coil. A one inch change in the setting of this coil will produce a frequency shift of approximately 125 kHz. Remember that the antenna tunes very sharply in this range and that high values of VSWR may be encountered only a few kHz either side of the lowest VSWR readings. It would be wise to take VSWR readings every 25 kHz or so to avoid "running past" the frequency of resonance and lowest VSWR. To minimize interference to other stations and to avoid erroneous readings, use only enough power to produce full scale deflection of the meter in the "forward" or "R.F. out" position.

   Once the proper coil setting has been found for the desired band segment, coil Q base matching (Q) at the base of the antenna may be adjusted for even lower VSWR. If earth losses are moderate to high, a good match may be possible if coil Q base matching (Q) is left fully compressed, if earth losses are low as with an extensive radial system, coil Q base matching (Q) may have to be stretched to twice its compressed length or more for a good match.

   In any case, a single setting for coil Q base matching (Q) should suffice for operation over most of 80/75 meters provided the 80 meter coil is readjusted for each different band segment.

2. Determine the frequency of minimum VSWR on 40 meters. The coil setting given earlier should produce resonance and lowest VSWR at approximately 7150 kHz. The 40 meter VSWR and resonance curve may be shifted in the same manner as on 80/75 meters by changing the settings of the upper coil clamp of the 40 meter coil. On this band the setting is much less critical and a one inch change in the clamp setting will shift the VSWR curve approximately 80 kHz. Be sure to loosen the clamp around tube (B3) that supports the 30 meter assembly and to reposition it as needed to avoid distorting the 40 meter coil.

3. Check VSWR on 20 meters. Tuning is quite broad on this band because the antenna is physically much taller than a quarter wavelength. To raise the frequency of lowest VSWR, reposition the 30 meter assembly so that the L clamp can be replaced on the next lower turn of the 40 meter coil, refer to step 27 in the assembly instructions. Alternatively, to lower the frequency of lowest SWR, reconnect the L clamp to the next higher turn of the 40 meter coil. In some cases, moving the tap point a full turn up or down may cause more of a frequency shift than is desired, in which case the entire 30 meter assembly may be rotated to permit adjustments of less than one full turn.

4. Check VSWR on 15 meters. The VSWR curve may be shifted upward or downward by changing the

length of the stranded wire between wire clamp 15M w/wire (L) and wire clamp 15M w/insulator (K). To raise the resonant frequency, simply shorten the wire by wrapping a longer "tail" back on itself and sliding the lower clamp upward to maintain tension. To lower the resonant frequency, feed more of the "tail" back through the hole in the insulator to increase the length of the wire between clamps L and K. A change of 2", 5 cm will shift the VSWR curve approximately 300 kHz.

5. Check VSWR on 10 meters. To raise the resonant frequency loosen the small hose clamp over the slotted end of tube (I) and slide tube (J) farther into tube (I). To lower the frequency, slide tube (J) farther out of tube (I) and re-tighten the hose clamp. A length change of 3" should move the VSWR curve approximately 200 kHz.

6. Check VSWR on 30 meters. To raise the resonant frequency, loosen the wing nut on the bottom coil clamp on coil/capacitor assembly 30 meter (P), stretch the coil and re-tighten the wing nut. To lower the resonant frequency, compress the coil. A change of only 1/4" will shift the VSWR curve approximately 100 kHz. Large changes in the setting of coil on coil/capacitor assembly 30 meter (P) may effect 20 and 40 meter tuning, in which case it may be necessary to repeat steps 2 and 3. In general, the point at which the 30 meter coil taps on to the 40 meter coil will be the major factor in 20 meter tuning.

7. Adjustments for 40, 30, 20, 15 and 10 meters should have little or no effect on the previous adjustments for 80/75 meters, but final VSWR check for this band should be made as in step 1 above.

8. In above ground installations it will usually be found that resonance and lowest VSWR occur at slightly higher frequencies on all bands compared to ground level installations. Therefore, on 15 and 10 meters, where length adjustments is the means of setting antenna resonance, it is recommended that the length of the stranded wire between wire clamp 15M w/wire (L) and wire clamp 15M w/insulator (K) be increased approximately 3" (7.5cm) and that tube (J) be extended approximately 6" (15cm) beyond the original dimensions given if an above ground installation is contemplated.

   These are merely recommended preliminary settings, for it is impossible to indicate precise settings that will produce resonance or lowest VSWR at a given frequency in all installations.

In the preceding steps it has been assumed that the antenna has been installed in a more or less clear spot away from other vertical conductors such as TV antenna feedlines, towers and masts, and that a minimal ground system or a system of resonant radials in the case of above ground installations, has been installed.

If these fairly basic conditions have not been met it is likely that resonance and low VSWR will be impossible on some or even all bands without an external matching device. One should bear in mind that VSWR, even with a resonant antenna, will depend in large measure on local ground conductivity, height above ground in the case of an elevated antenna, the extent of the radial, counterpoise or other ground system used, and on other factors over which the operator may have little or no control.

THEORY OF OPERATION

The HF6V-X / HF9V-X operates as a slightly extended quarter-wave radiator on 15 meters, a quarter-wave stub decoupler providing practically lossless isolation of the upper half of the antenna on that band. On 20 meters the entire radiator operates as a 3/8 wave vertical with much higher radiation resistance and VSWR bandwidth than conventional or "trapped" antennas having a physical height of on quarter wave or less. On 10 meters the HF6V becomes a 3/4 wave radiator with considerably greater radiation resistance and efficiency than quarter-wave trapped types. On 40 and 80/75 meters the L-C circuits that provided the inductive reactance for resonance on those bands also provide the capacitive reactance required for resonance on 20 meters.

On 30 meters, where the height of the antenna is slightly greater than a quarter wavelength, an additional L-C series circuit effectively "shorts out" a portion of the 40 meter inductor to provide an additional

resonance.

In order to minimize conductor and IR losses on 80 and 40 meters where the antenna is physically shorter than a quarter wavelength and thus operates with lower values of radiation resistance, large diameter self supporting inductors and low loss ceramic capacitors are employed.

Because the 20 meter radiation resistance is several times greater than that of conventional "trap" designs of the same height, an electrical quarter wavelength of 75-ohm cable is used as a "geometric mean" transformer to match the approximately 100 ohms of the 20 meter feedpoint impedance to a 50-ohm feedline of any convenient length.

If operation is desired on 160 meters, the 17 and 12 meter bands, or even 6 meters, add-on kits requiring no "surgery" are available from your Butternut dealer. NOTE: The A-17-12 and A-6 adapters are provided with the HF9V-X.

ELECTRICAL AND MECHANICAL SPECIFICATIONS

Shipping weight:	12 lbs/5.4 kg (HF6V-X) 14 lbs/6.4 kg (HF9V-X)
Height (adjustable):	26 ft/7.8 m
Feedpoint impedance:	nominal 50 ohms with included matching line
SWR at resonance:	1.5 or less—all bands
SWR bandwidth for 2:1 or less:	entire 10, 15, 20 and 30 meter bands; 250-300 kHz on 40 meters, 30-100 kHz on 75/80 meters
Power rating:	1500 watts PEP 80-10 meters; 400 w PEP on 30 meters
Wind loading area:	1.5 sq ft/0.15 sq m

GUYING

The antenna is designed to survive winds of up to 80 mph/125 kph without guying given the absence of ice-loading or heavy wind driven rain or sleet. In areas of frequent heavy winds a set of SHORT guys can be used to reduce the stresses that wind loading will impart to the lower sections of the antenna.

It should be noted that light nylon twine is totally unsuitable as guying material because it has too much stretch per unit length, although the heavier sizes of nylon rope (or even sash cord) may be suitable if used in short runs. Polyethylene rope may be used, but because some grades tend to deteriorate fairly rapidly, periodic inspections should be made.

A <u>single</u> set of guys placed just above the 30 meter circuit will be quite effective, provided that the guys retain a slight amount of slack and do not come off at too steep and angle. At angles of less than 45° the guys begin to exert a downward compressive force on the structure that can be more of a threat to survival than lateral wind loading on an unguyed structure.

Under no circumstances should guys be placed higher than 1/3 of the way up the antenna. The upper 2/3 of the antenna has little more than its own weight to support, so these sections may be allowed to bend with the wind with no serious risk of damage. It is the lower 1/3 of the antenna that must support both the weight of the upper sections and the wind loading on them and are thus more likely to receive damage in severe winds.

NOTES ON GROUND/RADIAL SYSTEMS FOR VERTICAL ANTENNAS

GROUND MOUNTING

A vertical antenna in its simplest form is electrically equivalent to one-half of a dipole antenna stood on end. When the antenna is mounted close to the ground, the earth below takes the place of the "missing" half of the dipole. If ground conductivity is fair to good, a short metal stake or rod may provide a sufficiently good ground connection for resonant and low SWR operation on the bands for which the antenna is designed. This basic arrangement is shown in figure one. In most every case, however, the efficiency of a vertical antenna will be greater if radial wires are used to improve ground conductivity as in figure two. Wire size is unimportant, and, in most ground-mounted installations, the radials may be any convenient length. They need not all be the same length, nor do they all need to be laid in a straight line. It is generally more convenient to slit the sod and to push the radials into the slits to a depth of several inches, but they may be left on the surface of the ground if they do not constitute a hazard. A large number of long radials will naturally be more effective in reducing ground losses than a small number of shorter ones, but one should remember that the greatest loss will occur in the earth near the base of the antenna where current flow is greatest. For this reason, it is generally better to use a larger number of radials of shorter length than a smaller number of longer ones for a given amount of wire.

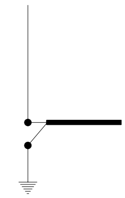


Figure 1

In some cases wire mesh (e.g., "chicken wire") may be used as a substitute for radial wires and/or a ground connection, the mesh or screen acting as one plate of a capacitor to provide coupling to the earth beneath the antenna.

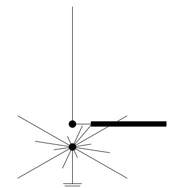


Figure 2

It should be noted that A GROUND ROD IS USEFUL ONLY AS A DC GROUND OR AS A TIE POINT FOR RADIALS. IT DOES NOTHING TO REDUCE RF GROUND LOSSES, REGARDLESS OF HOW FAR IT GOES INTO THE GROUND!

ABOVE GROUND MOUNTING

It is possible to operate a vertical antenna at any height above ground provided that something is done to supply the equivalent of a ground connection. It is NOT ENOUGH TO RUN A LONG LEAD TO A GROUND ROD OR COLD WATER PIPE, for current will flow in the lead, making it part of the overall antenna length and detuning the antenna. The usual approach to this problem is to install three or four <u>resonant</u> quarter-wave radials at the base of an elevated vertical and to connect them to the braid of the coaxial feedline as well as to the supporting mast or tower (if metal). Unlike the ground-mounted case, length of above ground radials is important, and the proper length(s) for any band may be found from the formula:

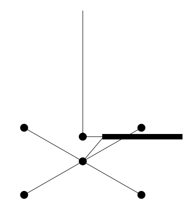


Figure 3

$$Length(ft) = \frac{240}{Frequency\,in\,MHz}$$

Four such radials, equally spaced, would be the equivalent of a highly conductive ground plane for any band at antenna base heights of one-half wavelength or more. In addition to providing a ground plane, radials of the proper length act as decoupling stubs to choke off current flow on any DC ground lead or grounded mast or tower, thus eliminating the detuning effect noted above. The basic ground plane system is shown in figure three. Radials may be run parallel to the earth or sloped downward any convenient amount without seriously affecting antenna feed point impedance or performance. Figure four shows a multi-band system using four separate sets of radials for 40, 20 and 10 meters. Inasmuch as the 40 meter radials are also resonant on 15 meters, a separate set is not required for that band. This same system will provide enough capacitive coupling to ground for operation on 75/80 meters at antenna base heights below about 40 feet in some cases, but since ground conditions vary widely, it is advisable to use at least one resonant 80 meter radial in an above-ground installation.

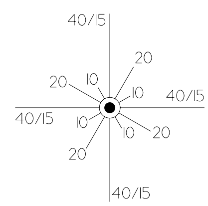


Figure 4

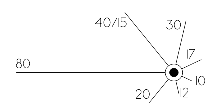


Figure 5

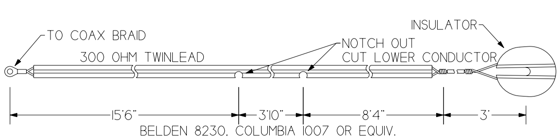


Figure 6

Figure five shows a simpler system which uses a single resonant radial for 80/75, 40, 30, 20, 17, 12 and 10 meters. With this arrangement, the antenna resembles a bent dipole on any one band, and the radiation pattern contains both horizontal and vertical components. The system in figure four, however, produces omnidirectional vertically polarized radiation. (Note: 30, 17 and 12 meter radials are not shown, but may be included in this type of system.)

Figure six illustrates the construction of a multi-band radial which is resonant on 40, 20, 15 and 10 meters. Good quality 300 ohm TV ribbon lead should be used (velocity factor is critical), and the conductors should employ at least on strand of steel wire to support the weight of the radial. Four such radials will be the practical equivalent of the system shown in figure four for operation on 80 through 10 meters.

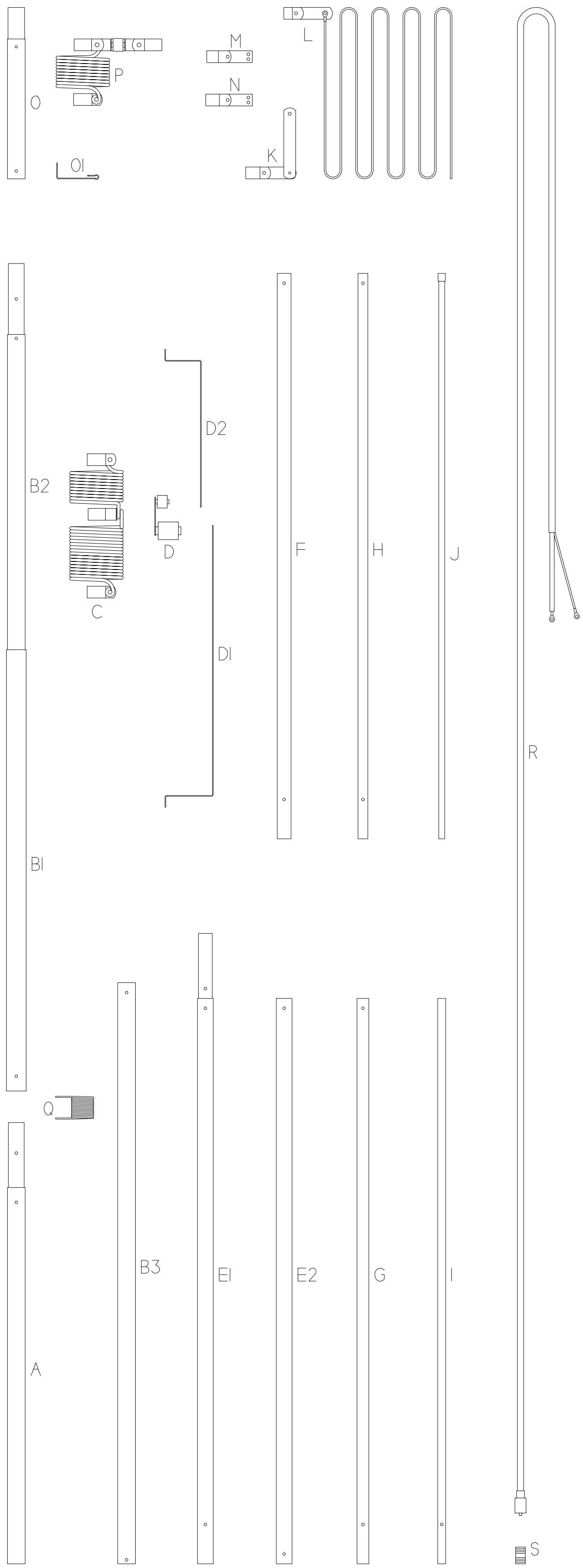
Regardless of the specific system used, radials should be well insulated at their far ends and kept clear of large masses of metal or other conductors that could cause detuning.

OTHER MOUNTING SCHEMES

In cases where a resonant vertical antenna may be neither ground mounted nor used with an elevated ground plane, operation may still be possible if connection may be made to a large mass of metal that is directly or capacitively coupled to ground, e.g., central air conditioning systems or structural steel frames of apartment buildings. Some amateurs have reported good results with vertical antennas extended horizontally or semi-vertically from metal terraces which serve as the ground connection. Alternatively, a quarter-wave vertical may be window mounted if a short ground lead to a cold water pipe or radiator can be used. If a long lead must be used, tuned radials will be required for resonance on one or more bands. GREAT CARE SHOULD BE EXERCISED IN SUCH INSTALLATIONS TO AVOID POWER LINES AND TO KEEP THE ANTENNA FROM FALLING ONTO PERSONS OR PROPERTY.

The metal shells of camper trailers, vans and mobile homes may also be used as ground systems for vertical antennas. Whenever possible, the antenna should be mounted with its base close to the top of the roof, and the shortest possible ground lead should be used. Even so, tuned radials may be required for low SWR on one or more bands.

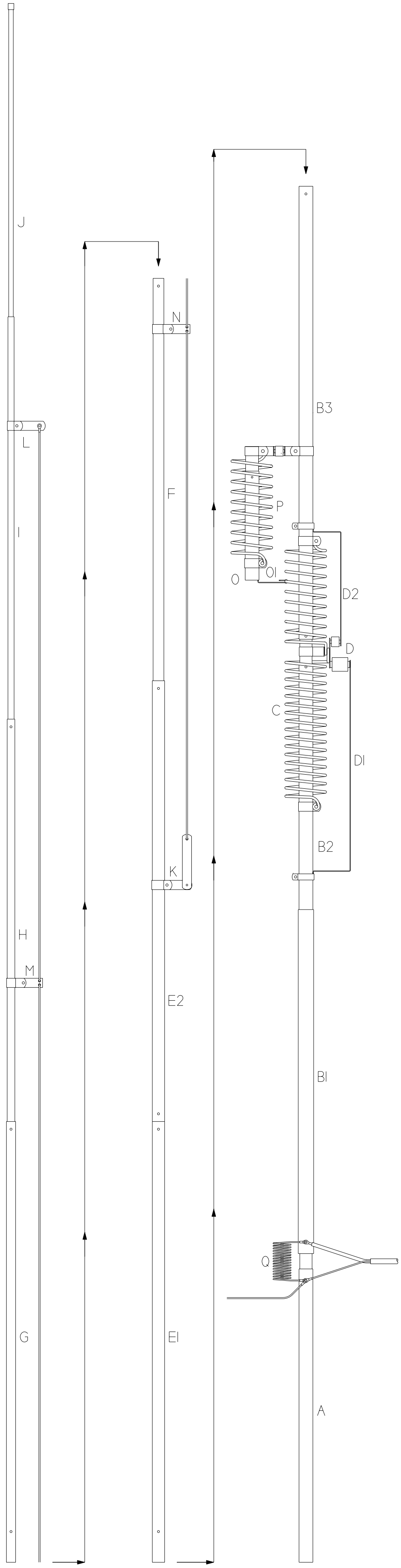
PARTS LIST



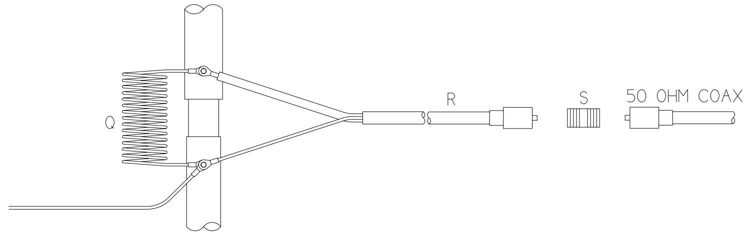
A	V00278	Tube A W/Insulator, 1 1/8" X 24"
B1	V00285	Tube B1 Section, 1 1/4" x 28"
B2	V00297	Tube B2 W/Insulator, 1 1/8" x 24"
B3	V00167	Tube B3, 1 1/8" x 36"
C	V00145	Coil Assembly 80/40 Meter
D	V00190	Capacitor Assembly 80/40 Meter
D1	V00150	Capacitor Bracket 80 Meter
D2	V00220	Capacitor Bracket 40 Meter
E1	V00284	Tube E1 W/Coupling
E2	V00170	Tube E2, 1" x 36"
F	V00171	Tube 0.875" x 36"
G	V00172	Tube 0.750" x 36"
H	V00173	Tube 0.625" x 36"
I	V00174	Tube 0.500" x 36"
J	V00175	Tube 0.375" x 36"
K	V00286	Wire Clamp 0.875" 15M W/Insulator
L	V00280	Wire Clamp 0.500" 15M W/Wire
M	V00281	Wire Clamp 0.625" 15M W/Insulator
N	V00282	Wire Clamp 0.750" 15M W/Insulator
O	V00204	Coil Support Tube 30 Meter
O1	V00176	Coil Support Tube 30 Meter L Bracket
P	V00249	Coil/Capacitor Assembly 30 Meter
Q	V00137	Coil Q Base Matching
R	V00223	Coax 75 Ohm Matching Line
S	V00228	Connector PL-258

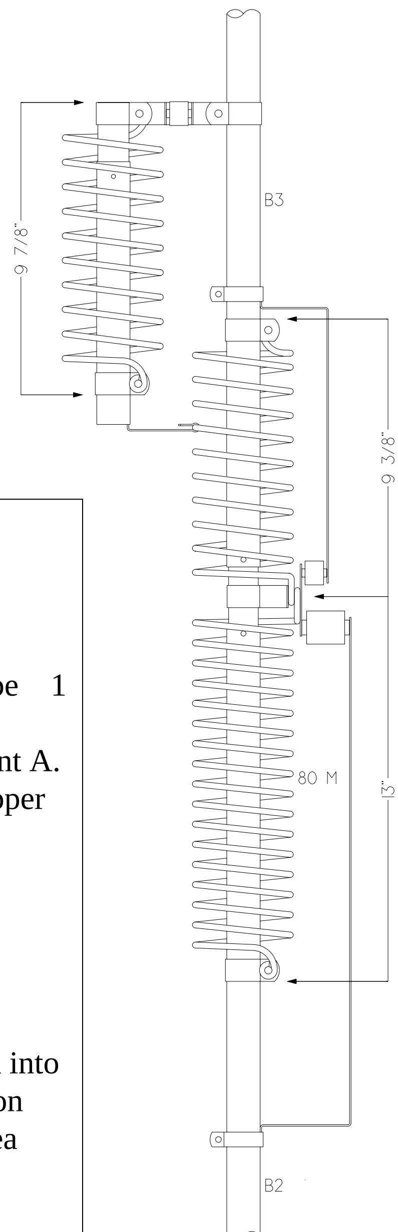
HARDWARE

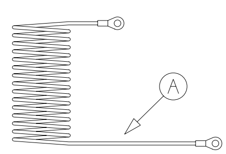
4	V00077	# 8 x 3/4" Screw
5	V00078	# 8 x 1" Screw
5	V00079	# 8 x 1 1/4" Screw
3	V00114	# 8 x 1 1/2" Screw
2	V00109	# 8 x 2" Screw
7	V00083	# 8 Flat Washer
20	V00080	# 8 Lock Washer
20	V00081	# 8 Hex Nut
2	V00131	#10 x 1" Screw
6	V00132	#10 Flat Washer
8	V00133	#10 Lock Washer
4	V00134	#10 Hex Nut
5	V00135	#10 Wing Nut
2	V00143	Capacitor Bracket Clamp
1	V00195	Large Adjustable Compression Clamp
1	V00144	Small Adjustable Compression Clamp
1	V00061	Butter-It's-Not
.05	V00050	Konnektor-Kote (1 x 8")



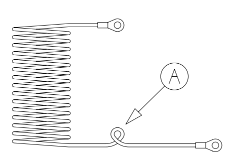
Feedline Detail







1. Use a knife to scrape 1 1/2" of enamel insulation from point A. Be sure that the copper is bright and clean.



2. Bend the clean area into a loop for connection later. The clean area may be tinned with solder.

IF YOU HAVE PROBLEMS...

Check out your installation again, looking for loose connections and checking all dimensions. Then refer to the list of possible symptoms below:

Symptom: Few or no signals heard: bands seem "dead", SWR is very high.
Look for: Open or shorted feedline, open or shorted matching line, broken connection at base of antenna (feedpoint).

Symptom: High SWR on 20m; other bands OK.
Look for: Missing matching line. Antenna not properly tuned. 20m radials not present or wrong length. Consult instructions for tuning and radial information; install matching line (RG-11 75 ohm coax, 11' 4" if solid dielectric, 13' 6" if foam type).

Symptom: High SWR on some bands, but signals heard on all bands (conditions permitting).
Look for: Missing or defective radial system. Install as per instructions and check connections to radials and ground system. Keep this connection 6" or less.

Symptom: High SWR on one band when antenna is roof-mounted. Radials are in place, but antenna will just not tune.
Look for: Radials of wrong length or running close to metal rain gutters or roof flashing. Tune radials and/or reroute them away from metal.

Symptom: Tuning is "sharp" with narrow bandwidth on 80m (and 160m if TBR 160 is in place).
Look for: Normal condition. The total length of the antenna represents such a small percent of a wavelength on these bands that sharp tuning is a normal condition.

Symptom: Antenna was installed on the ground and tuned OK, but tuning changed over a period of weeks or months.
Look for: Antenna installed over poor ground system. Ground conditions have changed, causing shift in resonance. Install radial system as per instructions. Check connection to radial system. When you see this problem, you may assume that a ground rod without a radial system is not enough.

Symptom: Resonant point changes during wet weather.
Look for: Normal condition.

Symptom: Insulation arcs over between 80m and 40m coils damaging fiberglass.
Look for: Operation at high power levels in areas where salt or pollution deposits have built up on the insulators. The cure is to keep insulators clean through routine maintenance.

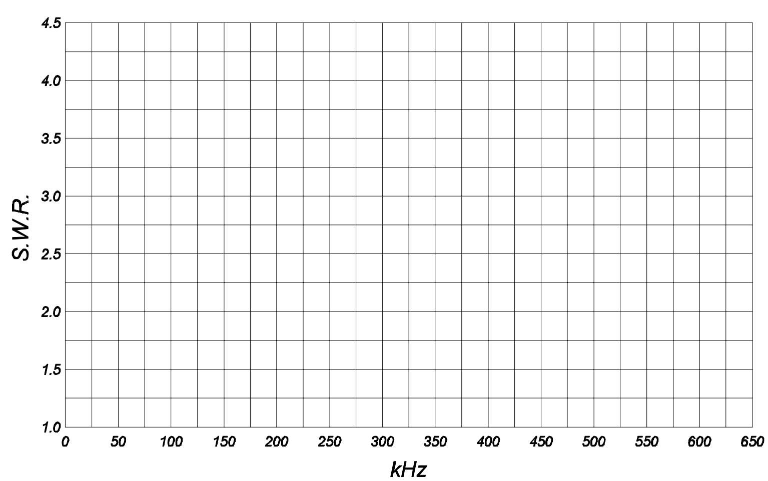
Symptom: Intermittent operation. SWR jumps up and down suddenly, and reception is also intermittent.
Look for: Loose connections in the feedline or matching line (if used). Bad relay in rig. Bad antenna switch or connecting cable. Broken or corroded connections at the feedpoint. Bad radial/ground connection. Radial or antenna contacting metal when wind blows. Loose hardware on the antenna. Check and secure all connections.

Symptom: Antenna displays generally degraded performance after long period of time.
Look for: Lack of routine maintenance. Coax may be waterlogged or damaged. Build up of salt or pollution deposits on insulators and capacitors. Radial system corroded or rotted away. Owner must do routine maintenance at intervals, according to local conditions.

Symptom: SWR is OK on 75m, but goes up gradually when high power is applied. This is accompanied by heating of 200pF capacitor.
Look for: Bad ceramic capacitor. Replace.

Symptom: Antenna doesn't tune 80m or 160m, even though radials are in place and of proper length.
Look for: Antenna far out of tune; operator has not followed systematic tuning procedure. Start with suggested settings in instructions. Make an SWR chart to determine point of resonance. Adjust coils *carefully!* Remember, tuning, is "sharp" on these bands, so it is easy to pass the resonant point, then assume erroneously that the antenna isn't tuning.

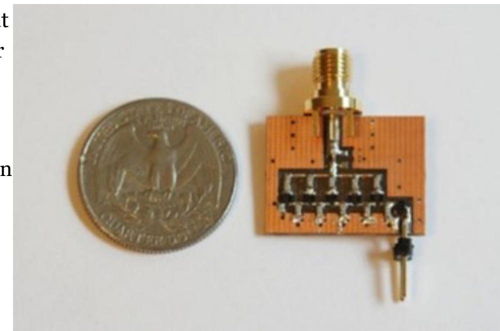
BEFORE you call the manufacturer for help, please double check your installation, including all connections and dimensions. Tune carefully and systematically. Have SWR curves available. Be prepared to describe your installation in detail.



RF Globalnet

From The Editor | October 7, 2013

Microwave Oven = Smartphone Charger: Will RF Energy Harvesting Make It Possible?



Imagine setting your dead smartphone down on the kitchen counter as you grab a frozen dinner out of the freezer. You pop the meal in the microwave, hit the start button, and *viola!* — 5 minutes later you have both a hot, nutritious meal *and* a charged phone. Sounds too good to be true, right?

Well, to be honest, it is too good to be true, at least today. However, the dream might not be as outlandish as it sounds, based on research presented at the Conference on Ubiquitous Computing in Zurich last month.

Yoshihiro Kawahara, an associate professor in the department of information and communication engineering at the University of Tokyo, presented findings demonstrating that electromagnetic energy leaked from a common microwave oven could be harvested and stored, and used to power electrical devices.

Microwave ovens work by passing non-ionizing microwave radiation — usually at a frequency of 2.45 GHz — through food. Contrary to popular (paranoid?) belief, very little energy actually escapes a microwave oven, even at very short distances from the appliance. Kawahara and his team, collaborating with researchers from the Georgia Institute of Technology, measured leakage of about 500 □□μW/cm^2 at a distance of 5 cm from the front of the oven door.

To capture this small amount of leaked power, Kawahara and his team designed a low-cost, energy-harvesting rectenna circuit tuned to the frequency of the microwave oven. The circuit consists of a dipole antenna and a custom-designed Dickson RF charge pump (about the size of a quarter — click on the thumbnail image above to view), which converts AC electrical power from a lower voltage to a higher DC voltage using a network of capacitors and diodes. During experiments, the antenna received instantaneous power levels of approximately 0.9 mW from the microwave oven when it was running. After 2 minutes of operation, the resistor consumed up to 8.87 mJ of maximum average power, and the capacitor stored up to 9.98 mJ.

According to the researchers, this amount of energy is sufficient to replace button batteries in powering low-power-consuming kitchen devices such as cooking thermometers, weight scales, and digital kitchen times. How long each could be operated by this power source varied anywhere from a few seconds to several minutes, depending on the device's energy requirements.

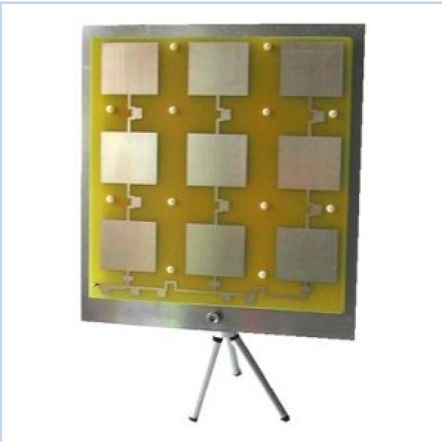
Which brings us back to my introduction's provocative and (overly) ambitious claim: Could this type of RF power harvesting technology eventually power your cellphone? Honestly, no time soon. Putting things in their proper context, if you fully discharge the battery on your iPhone, it will takes 5 minutes to establish even a minimum usable charge, and that's using a 5W power adapter. With Kawahara's rectenna, you would need to cook your TV dinner for a week or more to deliver a meaningful amount of power to your phone.

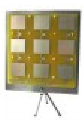
On the other hand, the researchers estimate that the amount of energy they were able to store was only about 15% of the ideal case, and they believe they can improve the circuit's performance by using more sophisticated impedance matching and power management methods. Plus, the energy efficiency of electronic devices continues to improve, meaning their energy requirements will continue to drop. As a result, the technology could conceivably charge several low-power devices at once, power individual devices enough for longer operation, or even power more energy-hungry devices.

Though cell phone charging may still be a stretch, Kawahara has a grander vision for his energy harvester than powering up kitchen thermometers. He has published research on the potential development of autonomous wireless sensor networks that would scavenge the few dozen milliwatts needed for operation from ambient RF signals. His ultimate vision includes "thin and fluffy" wireless sensor nodes that could be carried by the wind and cover large areas like the "petals of a blossom."

Such applications may sound fanciful, but RF energy harvesting is definitely an up-and-coming research area in the industry. At IMS2013 earlier this year, I sat in on a well-attended technical session on the topic, where researchers presented their novel techniques for harvesting and transmitting energy at different frequencies. (A paper by Kawahara and collaborators was presented during a separate technical session on RF energy scavenging at the conference, but I wasn't able to attend.) It will be interesting to see how this technology develops in the coming years to one day power satellites, sensors, appliances, and, just maybe, your smartphone.

19DBI 2.4GHZ HIGH GAIN PANEL ANTENNA





High gain 2.4gHz 19 dBi patch antenna.

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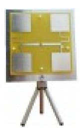
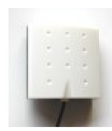

14dBi 2.4gHz...


11dBi 2.4gHz...


18 dBi 5.8...


12dBi 5.8...


14dBi 5.8...


5.8 gHz 11...


MULTI...


5.8 gHz 9...


24 dBi 5.8...

19 dBi panel antenna.
Sizes 26x27 cm.
Horizontal & vertical beam width: 17 **degrees**

Package contains:
19 dBi antenna.
1 meter SMA connection cabel
Tripod.

ANTENNAS

Home-made antennas can greatly improve the performance of AM and FM radios, short-wave receivers, and scanners. If you are a talk-radio fan then experiment with the AM band antennas and you will be able to hear shows from all over the country with surprising clarity. Short-wave receivers are always coping with weak signals and they must have a good antenna to perform adequately. Scanners can pick up local police and two-way radio with the little telescoping antenna provided but with good antennas a scanner becomes an amazing ear on the world nearby. No pre-amp, filter or other receiver refinement offers anywhere near the level of performance improvemen t that a well-designed antenna offers. The results can be quite satisfying, leaving no doubt that the project was well worth the effort.

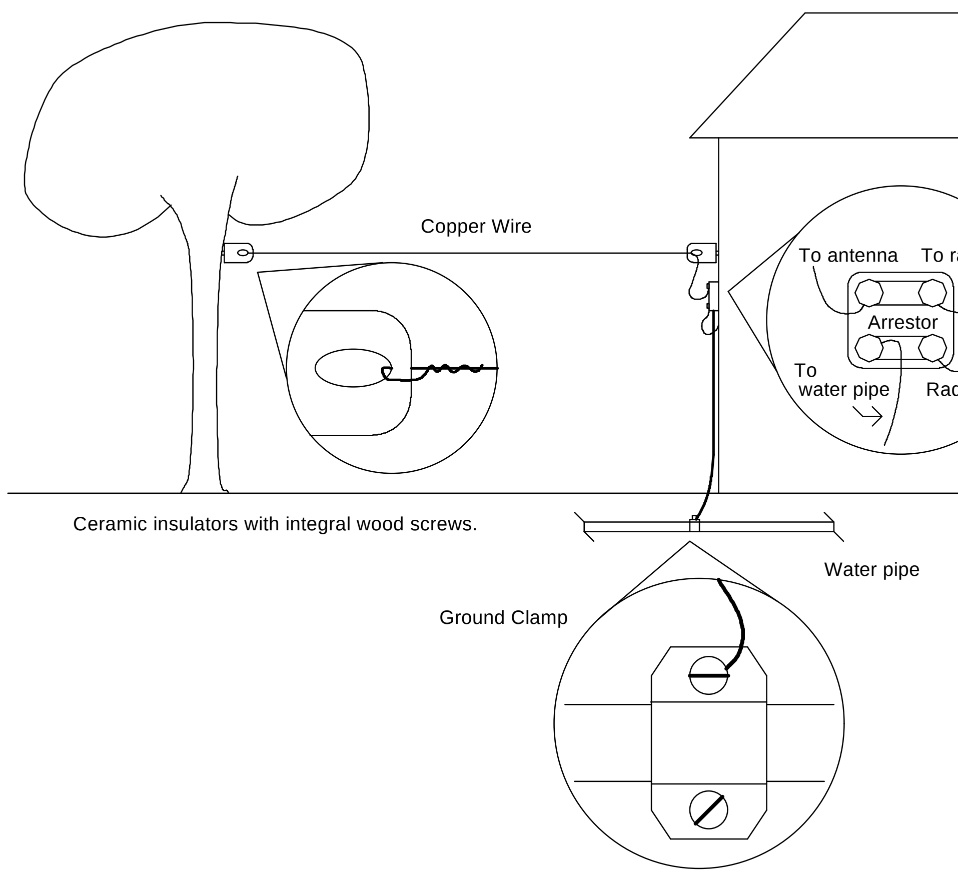


Figure 1: Long wire antenna for AM and shortwave radios.

AM Band Antennas

A good AM Band antenna can be a simple long-wire strung between two trees or across the top of the roof. Even a modest length wire will give your receiver greatly improved reception

with less static because the signal pickup is occurring some distance from the interference generating appliances in the house. An insulator mounted high in a tree so that the wire has a large vertical rise will give great results. Mount the antenna as high and as far from the house as practical. Use a good quality ceramic insulator for holding the wire and add a commercial lightning arrestor where the antenna meets the house (Fig.1). Ceramic insulators are available with built-in wood screws and can be screwed into a tree or the wood parts of the house by hand. A good place for the arrestor is directly above the point where the water line enters the house. Run a heavy gauge ground wire straight down to the water pipe and attach it with a brass grounding clamp. This connection also makes an excellent ground for the receiver. A shielded cable lead-in wire can give improved results when the residence has unusually noisy appliances. If you do not have an AM radio with a coaxial antenna jack then consider using an auto radio. Auto radios are well shielded to prevent ignition noise from interfering with reception and all that is needed to make a superior receiver for the home is a 12 volt power supply and a speaker. Inexpensive AM car radios are quite common, being discarded for fancy stereo upgrades and even the cheapest car receiver will outperform most home radios.

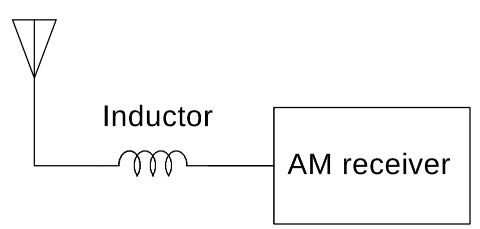


Figure 2: Adding a loading coil to the antenna.

In the event that a little more signal strength is desired, fig. 2 shows how to add a loading inductor to the antenna. Most long wire antennas will be considerably less than 1/4 wavelength at AM band frequencies and behave as though a small capacitor is connected in series. The inductor resonates with this capacity and will increase the signal strength significantly. Obviously, the required inductance varies with the received frequency. The values typically range from about 200 microhenry at the high end of the band to about 2 millihenry at the bottom end of the band for a 20 foot antenna.

Fig. 3 shows how to build a programmable loading coil using a 4.5 inch PVC coupling (found in the plumbing supply area of the local home improvement store) and 22 gauge insulated wire. The coil is wound with 100 turns with taps brought out every 10 turns by twisting a little loop in the wire.

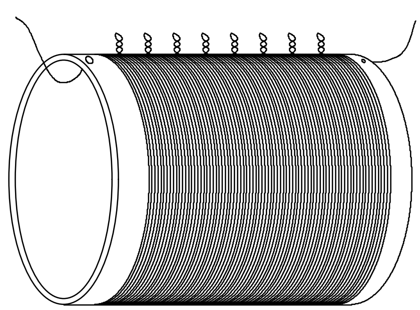


Figure 3: Multi-tapped loading coil wound on 4.5 inch PVC coupling.

The total inductance of this inductor is about 1 millihenry so short antennas may need more turns for the lower frequencies. Fixed inductors and a multi-position switch can be used to build a more compact and convenient unit shown schematically in fig.4.

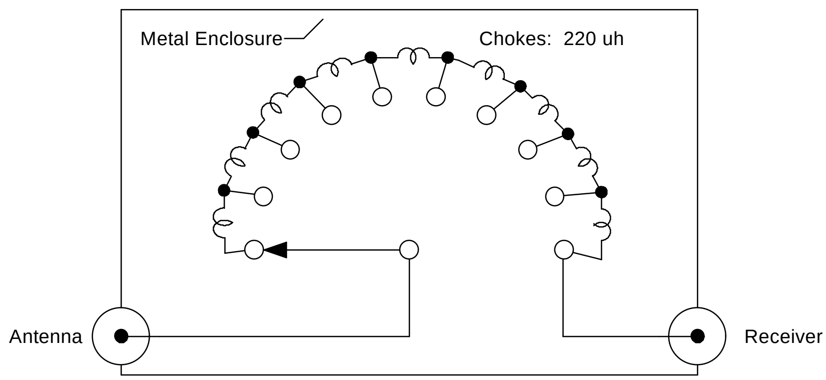


Figure 4: Adjustable loading coil built with a 10-position switch.

220 microhenry chokes are shown to give enough inductance to handle shorter antennas but other values may be used depending on the application. Remember, a loading inductor is probably not needed unless the signal strength is too low or fading.

A directional antenna may be constructed with a ferrite rod and amplifier as shown in fig.5. A ferrite rod 5/16 inches in diameter and 7 inches long was wound with 90 turns which gave sufficient inductance (about 300 uh) to cover the AM band without tuning and gave good reception well into the short-wave band. Experiment with whatever loopstick is available but larger is better.

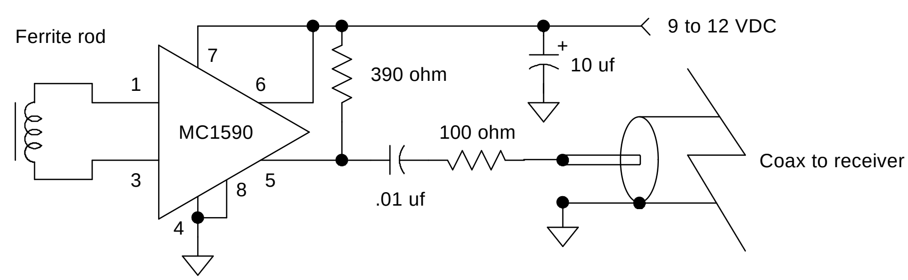


Figure 5: Ferrite antenna with built-in amplifier.

The MC1590 differential amplifier may be constructed on a small piece of copper-clad circuit board material using the copper board for ground connections. The amplifier should be mounted near the ferrite loopstick with the coax and power wire leading to the radio. No separate ground wire is shown since the coax shield will serve both purposes. The loopstick and amplifier may be slipped into a piece of 13/8 inch PVC with a cap on one end and a right angle coupling and pipe on the other (Fig. 6).

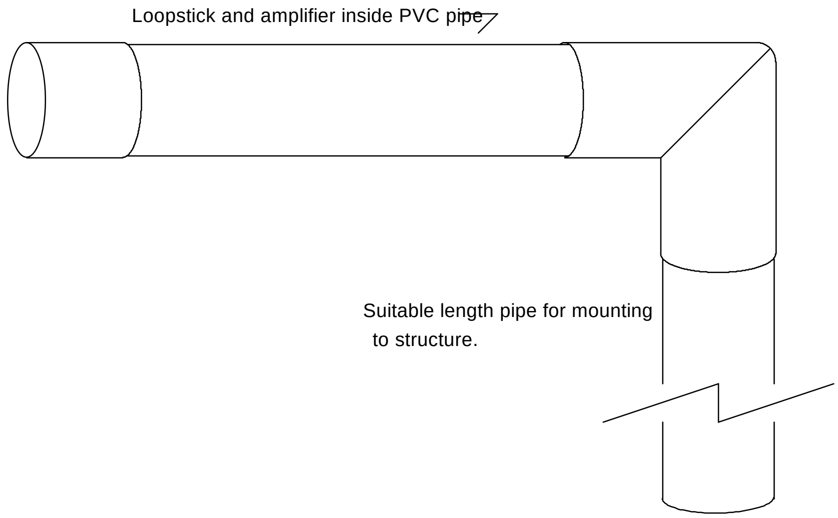


Figure 6: PVC enclosure for loopstick antenna.

The vertical pipe may be secured to the outside wall of the house with clamps loose enough to allow the antenna to be aimed. The wires can simply hang out of the bottom of the tube without any seal or a little squirt of foaming urethane caulking could be used to seal the pipe. Ground the coax to the cold water pipe for lightning protection if the loop is outside and high.

A totally different approach to low frequency antennas is shown in fig.7. A very short antenna can give amazing results, often performing as well as a long wire antenna if the proper buffer amplifier is added between the radio and the antenna. The electrical model of a short antenna includes a very small series capacitor - so small that little signal gets through and the required resonating loading coil is impractically large. However, if the antenna is connected to a high impedance buffer with a very low input capacity, the antenna capacity will not attenuate the signal significantly. The amplifier must have good intermodulation characteristics so that phantom stations don't appear all over the dial and the antenna must be kept short to prevent amplifier overload. Don't connect this circuit to a long wire antenna unless you are curious to hear what radio chaos sounds like.

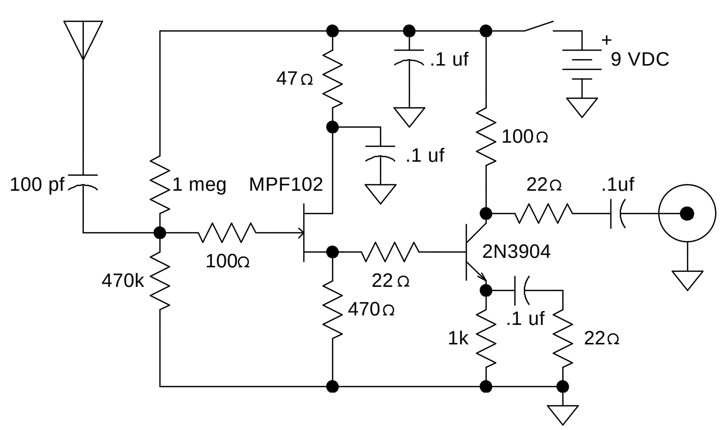


Figure 7: Short antenna buffer/amplifier.

The N-channel JFET shown is a MPF102 but other types may be substituted. The antenna may be a few inches to about 6 feet but avoid using longer antennas. With the values shown the buffer will work well from below 100 kHz to about 15 MHz which covers the frequency range where an antenna buffer is useful.

For higher frequencies, a resonant antenna becomes feasible. For example, Fig. 8 shows a simple vertical ground-plane antenna which connects directly to 50 ohm coaxial cable without a loading coil or matching network. Using the equations shown, a 49 MHz antenna would have a vertical element 57 inches long and ground elements 59 inches long. The vertical element simply connects to the center conductor of the coax and the ground elements connect to the coax braid. The elements may be mounted on a small square of phenolic, fiberglass, or other weatherproof board material. Try not to let dissimilar metals come in contact or, if they must, coat the contact area with silicone rubber. One simple approach is to make the whole affair from PVC pipe with copper wire or tubing on the inside.

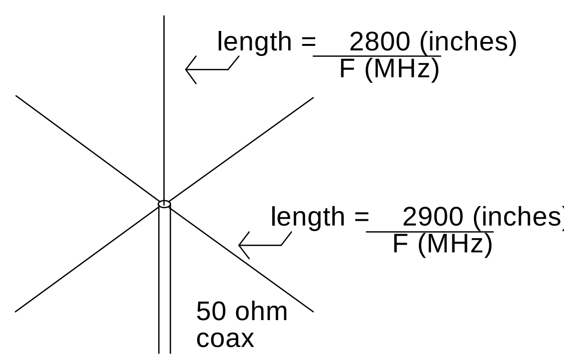


Figure 8: Vertical ground-plane schematic.

It is often desirable to have a fixed-frequency antenna with directionality for monitoring a particular station or for installing on an antenna rotator. For example, if you live within a mile or two of a fast food restaurant you can probably pick up the little wireless microphones they use to take orders. You are probably wondering why anyone would want to pick up those signals (which are around 33 MHz). Hmmm. Well, it would be a challenge. Or, how about building a dedicated antenna to receive a distant weather transmitter instead. Or the police in a neighboring town, or a remote airport. Those sound a little better. The point is that a directional antenna will give greatly improved performance for any of the signals on your scanner.

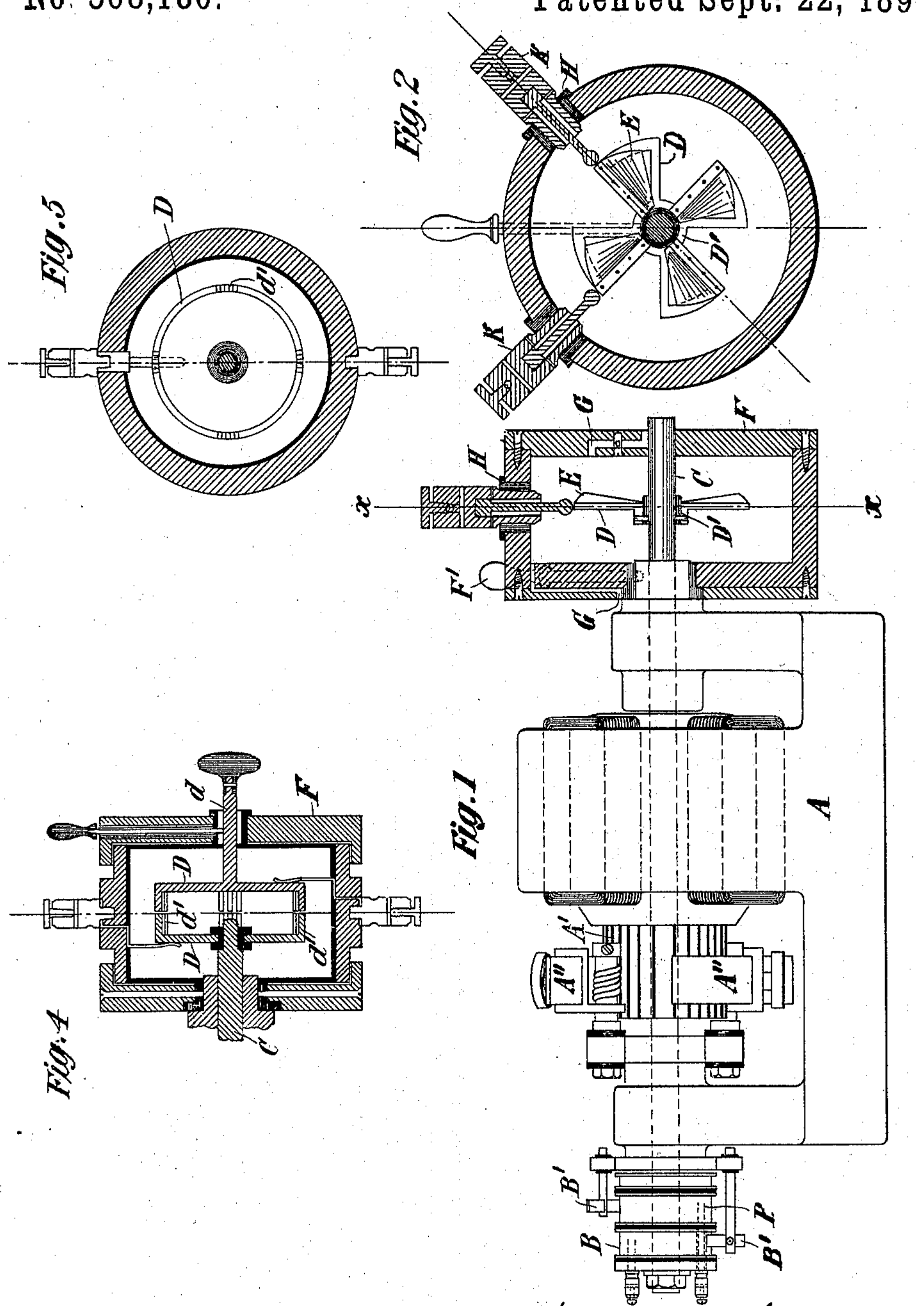
Multi-element yagi antennas are a good choice for single frequency reception and log-periodic antennas give excellent multi-band reception. The construction of these antennas can prove difficult and purchasing a factory assembled unit is usually a preferable approach.

(No Model.) 2 Sheets—Sheet 1.

N. TESLA.

APPARATUS FOR PRODUCING ELECTRICAL CURRENTS OF HIGH FREQUENCY.

No. 568,180. Patented Sept. 22, 1896.



WITNESSES:

Edwin B. Hopkinson.

Benjamin [illegible]

Nikola Tesla, INVENTOR

BY

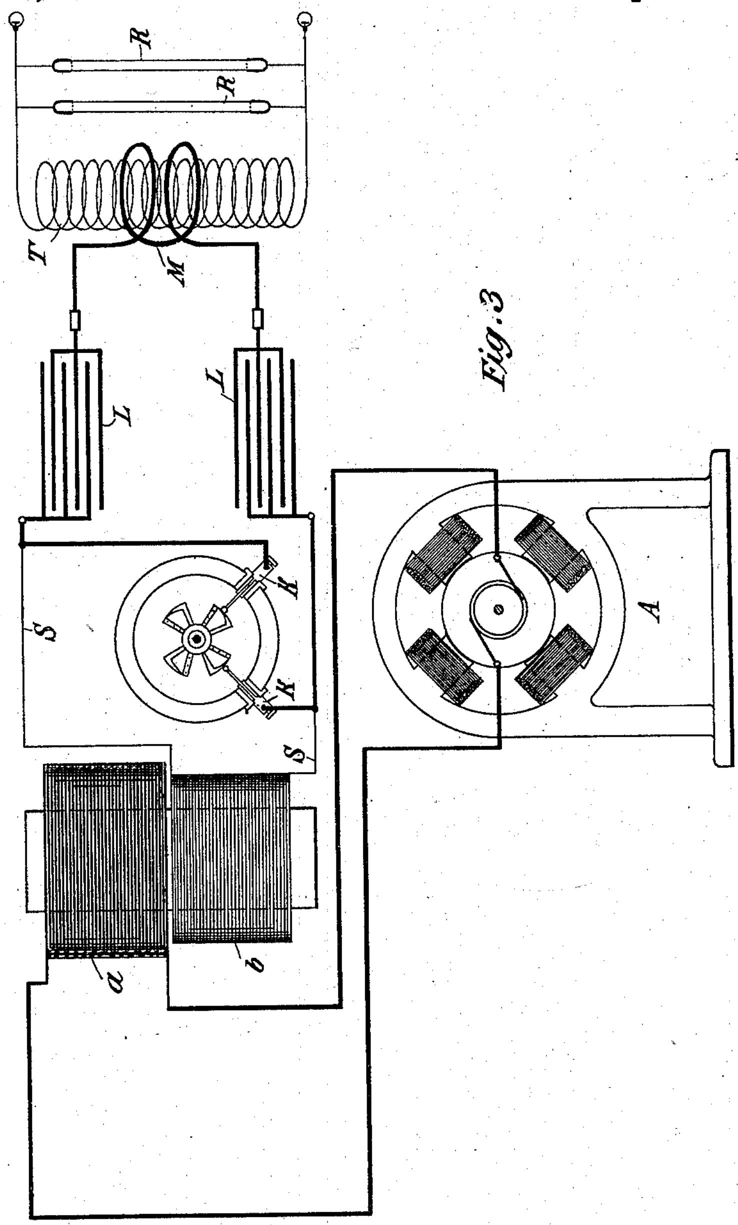
Kerr, Curtis & Page, ATTORNEYS

(No Model.) 2 Sheets—Sheet 2

N. TESLA.

APPARATUS FOR PRODUCING ELECTRICAL CURRENTS OF HIGH FREQUENCY.

No. 568,180. Patented Sept. 22, 1896.



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Nikola Tesla INVENTOR

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Kerr, Curtis & Page, ATTORNEYS

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR PRODUCING ELECTRICAL CURRENTS OF HIGH FREQUENCY.

SPECIFICATION forming part of Letters Patent No. 568,180, dated September 22, 1896.

Application filed July 9, 1896. Serial No. 598,552. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Apparatus for Producing Electrical Currents of High Frequency, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

This invention is an improvement in apparatus for producing electrical currents of high frequency in accordance with the general plan heretofore invented and practiced by me and based upon the principle of charging a condenser or circuit possessing capacity and discharging the same through a circuit of low self-induction, so that rapid electrical oscillations are obtained. To secure this result, I employ some means for intermittently charging the condenser and for discharging it through the circuit of low self-induction; and among the means which I have heretofore employed for this purpose was a mechanical contact device which controlled both the charging and the discharge circuit in such manner that the condenser was alternately charged by the former and discharged into the latter.

My present improvement consists in an apparatus for effecting the same result by the use of a circuit-controller of special character in which the continuity of the paths for the current is established at intervals by the passage of sparks across a dielectric.

In carrying out my present improvement I employ a circuit-controller containing two terminals or sets of terminals movable with respect to each other into and out of proximity, and I provide means whereby the intervals between the periods of close approximation, during which the spark passes, may be adjusted so that when used in a system supplied by a source of alternating current the periods of make and break may be timed with reference to a phase of the current wave or impulse.

Referring to the drawings, which illustrate in its preferred form the improvement above referred to, Figure 1 is a view, partly in elevation and partly in section, of a generator arranged to give an alternating current with the circuit-controller mounted on its shaft. Fig. 2 is a section of the controller of Fig. 1 on line $x\,x$ of said figure. Fig. 3 is a diagram illustrating the system or apparatus as a whole. Figs. 4 and 5 are sectional views of a modified form of circuit-controller.

A designates in Fig. 1 a generator having a commutator A′ and brushes A″ bearing thereon, and also collecting-rings B B, from which an alternating current is taken by brushes B′ in the well-understood manner.

The circuit-controller is mounted in part on an extension of the shaft C of the generator, and in part on the frame of the same, or on a stationary sleeve surrounding the shaft. Its construction in detail is as follows: D is a metal plate with a central hub D′, which is keyed or clamped to the shaft C. The plate is formed with segmental extensions corresponding in number to the waves of current which the generator delivers. These segments are preferably cut away, leaving only rims or frames, to one of the radial sides of which are secured bent metal plates E, which serve as vanes to maintain a circulation of air when the device is in operation. The segmental disk and vanes are contained within a close insulated box or case F, mounted on the bearing of the generator, or in any other proper way, but so as to be capable of angular adjustment around the shaft. To facilitate such adjustment, a screw-rod F′, provided with a knob or handle, is shown as passing through the wall of the box. The latter may be adjusted by this rod, and when in proper position may be held therein by screwing the rod down into a depression in the sleeve or bearing, as shown in Fig. 1. Air-passages G G are provided at opposite ends of the box, through which air is maintained in circulation by the action of the vanes. Through the sides of the box F and through insulating-gaskets H, when the material of the box is not a sufficiently good insulator, extend metallic terminal plugs K K, with their ends in the plane of the conducting segmental disk D and adjustable radially toward and from the edges of the segments. This or similar devices are employed to carry out the invention above referred to in the manner illustrated in Fig. 3. A in this figure represents any source of alternating current

the potential of which is raised by a transformer, of which a is the primary and b the secondary. The ends of the secondary circuit S are connected to the terminal plugs K K of an apparatus similar to that of Figs. 1 and 2 and having segments rotating in synchronism with the alternations of the current source, preferably, as above described, by being mounted on the shaft of the generator when the conditions so permit. The plugs K K are then adjusted radially, so as to approach more or less the path of the outer edges of the segmental disk, and so that during the passage of each segment in front of a plug a spark will pass between them, which completes the secondary circuit S. The box or the support for the plugs K is adjusted angularly, so as to bring the plugs and segments into proximity at the desired instants with reference to any phase of the current-wave in the secondary circuit and fixed in position in any proper manner. To the plugs K K are also connected the terminals of a condenser or condensers L, so that at the instant of the rupture of the secondary circuit S by the cessation of the sparks the energy accumulated in such circuit will rush into and charge the condenser. A path of low self-induction and resistance, including a primary M of a few turns, is provided to receive the discharge of the condenser, when the circuit S is again completed by the passage of sparks, the discharge being manifested as a succession of extremely rapid impulses. The potential of these impulses may be raised by a secondary T, which constitutes the source of current for the working circuit or that containing the devices R for utilizing the current.

By means of this apparatus effects of a novel and useful character are obtainable, but to still further increase the efficiency of the discharge or working current I have in some instances provided a means for further breaking up the individual sparks themselves. A device for this purpose is shown in Figs. 4 and 5. The box or case F in these figures is fixedly secured to the frame or bearing of the generator or motor which rotates the circuit-controller in synchronism with the alternating source. Within said box is a disk D, fixed to the shaft C, with projections d' extending from its edge parallel with the axis of the shaft. A similar disk D'' on a spindle d, in face of the first, is mounted in a bearing in the end of the box F with a capability of rotary adjustment. The ends of the projections d' are deeply serrated or several pins or narrow projections placed side by side, as shown in Fig. 4, so that as those of the opposite disks pass each other a rapid succession of sparks will pass from the projections of one disk to those of the other.

What I claim as my invention is—

1. The combination with a source of current, of a condenser adapted to be charged thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit-controller for effecting the charging and discharge of said condenser, composed of conductors movable into and out of proximity with each other, whereby a spark may be maintained between them and the circuit closed thereby during determined intervals, as set forth.

2. The combination with a source of alternating current, of a condenser adapted to be charged thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit-controller for effecting the charging and discharge of said condenser, composed of conductors movable into and out of proximity with each other in synchronism with the alternations of the source, as set forth.

3. A circuit-controller for systems of the kind described, comprising in combination a pair of angularly-adjustable terminals and two or more rotating conductors mounted to pass in proximity to the said terminals, as set forth.

4. A circuit-controller for systems of the kind described, comprising in combination two sets of conductors, one capable of rotation and the other of angular adjustment whereby they may be brought into and out of proximity to each other, at determinate points, and one or both being subdivided so as to present a group of conducting-points, as set forth.

NIKOLA TESLA.

Witnesses:
M. LAWSON DYER,
DRURY W. COOPER.

THE HANDYMAN'S GUIDE TO OSCILLOSCOPES (Part 2 of 2)

by Paul Harden, NA5N

Making some advanced measurements with your Oscilloscope

Print as .pdf file
4 pages
8½ x 11 or A4

In Part 1, oscilloscope operation was covered for making basic voltage, time and frequency measurements. In this part, we'll continue with some more advanced uses of a scope, and in particular, how to use a scope for testing and troubleshooting ham radio QRP transceivers in the homebrewer's workshop.

Receiver Filter Bandwidth.

This procedure uses a scope (a DVM can be used with less accuracy) for determining the overall filter bandwidth (or selectivity) of a receiver. It is basically measured by plotting output voltage vs. audio frequency to construct a picture of the filter response.

Connect scope to the receiver audio output (speaker or phone jack); measurement will be based on peak-to-peak voltages (Vpp) on a scope, or rms voltage (Vrms) on a DVM.

Using a signal generator, set the frequency for the band of interest on your radio. For example, on a general coverage shortwave receiver, you might set it for 10 MHz (top end of the 31M band), or perhaps to 7.040 MHz on a 40M ham radio receiver/transceiver. Tune the receiver to the signal generator signal. If you don't have a signal generator, you can also tune to a steady carrier or station to produce a hetrodyne audio "pitch." Tune in the signal to the pitch that causes the maximum peak-to-peak display. Adjust the scope and volume control to produce a 2Vpp display (4 divisions). This is the peak response of the overall filtering stages as shown in **Fig. 13**.

Now determine the audio frequency at this peak response by measuring the time period between cycles and covert to frequency. In the example to the right, the period of one cycle is 1.7mS, which is an audio tone of 750Hz (1/.0017sec). A frequency counter on the output can also be used.

Next, tune the receiver such that the sidetone pitch goes UP in frequency and the peak-to-peak signal will decrease in magnitude. Tune to the point where the signal is exactly 1Vpp on the scope. See **Fig. 12**.

This is the –6dB point of the high end of the filter (20log 1v/2v =–6dB). Determine the frequency of the audio pitch as before. In the example, this is 1100 Hz. Record the data.

From these two data points, the –6dB bandwidth can be estimated. The bandwidth from the filter peak (750 Hz) to the –6dB point (1100 Hz) is 350 Hz. The bandwidth (BW) between the two –6dB points is usually twice this value, or 700 Hz. A filter with a –6dB BW of 700Hz is a mediocre filter for CW reception, and way too narrow for SSB or AM.

Of course you can determine the exact –6dB BW by tuning the receiver back to the 2Vpp peak response, and continue tuning DOWNward in frequency until the audio is again exactly 1Vpp. Determine this frequency and record. In this example, it should occur around 400 Hz if the filter shape is symmetrical.

Plot these three data points on a sheet of graph paper as shown in **Fig. 15** to construct the filter shape. Return to the upper –6dB point (1100Hz in the example) and continue tuning upwards in audio pitch, recording the frequency at 0.5v (–12 dB), 0.25v (–18 dB), 125mV (–24 dB), etc. Everytime you "halve the voltage," it is a 6 dB change. The more points you collect, the more accurate your filter response plot will be.

Fig. 13 – Displaying Filter Peak Response

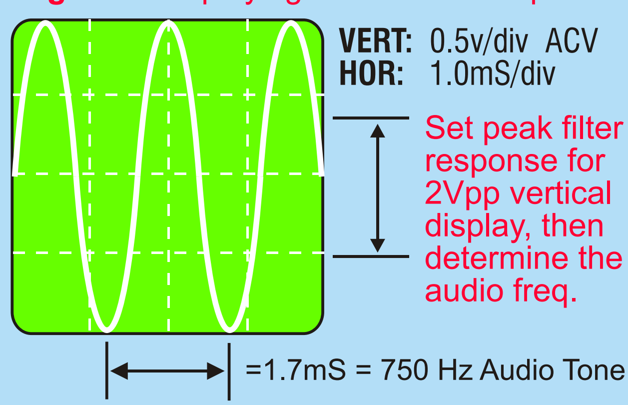
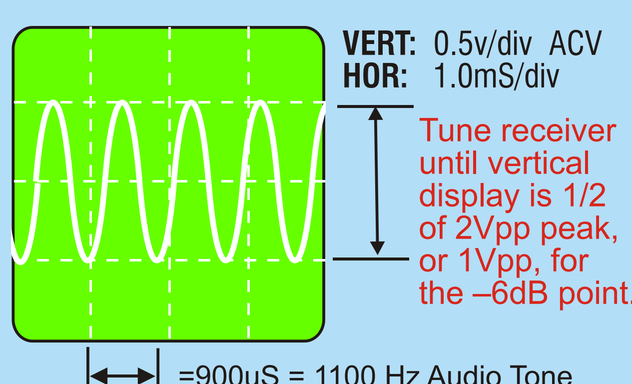
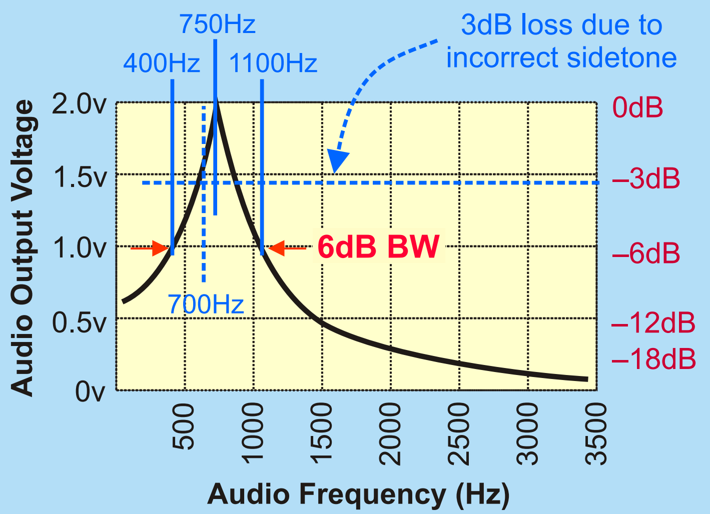


Fig. 14 – Displaying –6dB Frequency



Of interest to proper rig alignment is to repeat the above using the output of the product detector. To maximize the effectiveness of the filtering, the receive offset frequency set by the BFO should be adjusted to the same frequency as the peak frequency response of the audio. In this example, with the peak audio response occuring at 750Hz, if your BFO is set for a sidetone frequency of 700 Hz, you are loosing 2–3 dB, since this is in your filter skirt. This is shown on the response plot in **Fig. 15** by the dashed lines. By adjusting your BFO for a sidetone frequency of 750 Hz, you will pick up 3-4dB of overall gain in your receiver, plus increase the selectivity a bit as well. Why? Because nearby stations, such as one at 800–900Hz tone, could actually be louder than the 700Hz tone signal you are trying to copy, since the gain of the receiver is greater at those tones than at 700Hz, as shown in the plot.

Fig. 15 – Plotting Audio Response

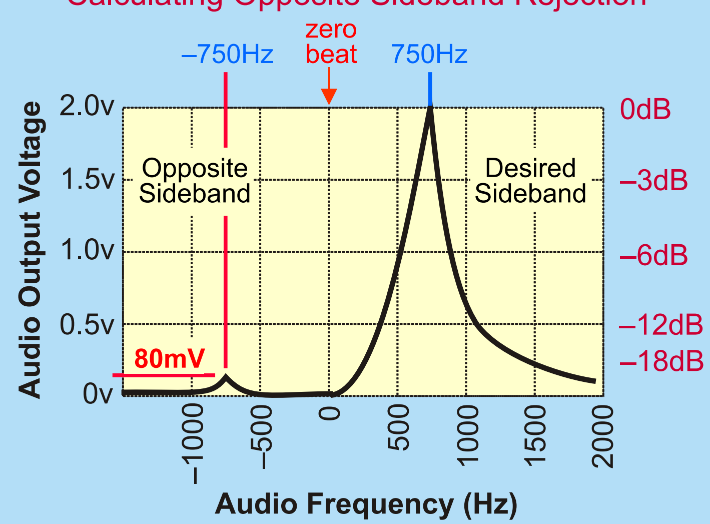


Opposite Sideband Rejection

A superhet receiver is supposed to pass just one sideband and reject the other. Poor opposite sideband rejection could indicate the crystals in your IF filter are not well matched or other problems. It is measured almost identical to plotting the filter response just described. First, you tune the receiver to the test signal to find the peak response frequency, or 750Hz in this example. Set the scope display for 2Vpp. Now tune downward in audio pitch, passing zero-beat, and continue tuning and you should hear the test signal, much weaker, now rising again in tone. This is the *opposite sideband*. Measure the peak-to-peak voltage, if you can. For example, say it is 80mVpp, as shown in **Fig. 16**. Calculate the opposite sideband rejection by:

$$\text{rejection} = 20\log \frac{80\text{mV}}{2.0\text{v}} = \frac{80\text{mV}}{2000\text{mV}} = -28\text{dB}$$

Fig. 16
Calculating Opposite Sideband Rejection



If you can't hear the opposite sideband, then obviously you have excellent filter rejection. If you can just barely hear it, you may have to increase the sensitivity of your scope (set vertical gain to 20 or 50 mV/div). In this example, –28dB rejection of the opposite sideband is quite good. A –30dB rejection means the opposite sideband is only 1/1000th of the desired sideband, a very suitable attenuation of the opposite sideband.

These tests are important to perform on your rig for documenting it's current performance, and repeated periodically to detect unfavorable changes or for troubleshooting when a problem is evident. For homebrewing, these tests can allow you to evaluate different circuits or when experimenting with different components or part values.

Oscillator Phase Noise

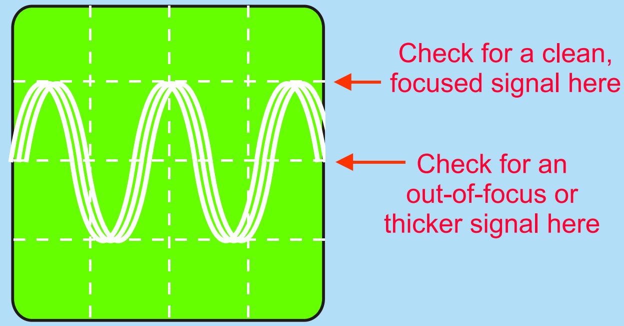
When homebrewing a basic oscillator circuit, such as a VFO, looking at the oscillator output on a scope can reveal several problems. One is to check for excessive phase noise. Phase noise is small variations of the oscillator frequency that causes power in the close-in sidebands, usually measured on laboratory equipment within 100KHz, or even within 10 KHz.

To check for oscillator phase noise, connect the oscilloscope to the oscillator output, loading the output of the oscillator as little possible. Most scopes have sufficiently high input impedances where this shouldn't be a problem, but some cheaper scopes can load an oscillator circuit. If you suspect your scope is loading the oscillator, couple the scope to the circuit with a small value capacitor, less than 20pF.

Display 2–3 cycles of the oscillator output as shown on the scope display shown in **Fig. 17**. Properly focus the scope and carefully observe if the waveform appears in focus at the peaks, but slightly out-of-focus at the zero-crossing points, that is, on the rising and falling edges of the sine wave.

If it appears out-of-focus, this is excessive phase noise jittering the signal and "smearing" the waveform along the time (horizontal) axis. Extreme phase noise may show 2-3 sine waves very close to each other, as shown in the exagerated waveform to the right — assuming you have your scope properly triggered.

Fig. 17 – Checking Oscillator Phase Noise



Phase noise is random, instantaneous changes in the oscillator frequency that smears the display. If you can see this on a scope, the phase noise is excessive! If you can't see it, it doesn't mean the oscillator has no phase noise (all oscillators have some phase noise), it just means it is not excessive enough to see on a scope. A scope is not a good instrument for checking phase noise, but for homebrew circuits, it is a check to ensure you do not have a serious oscillator problem.

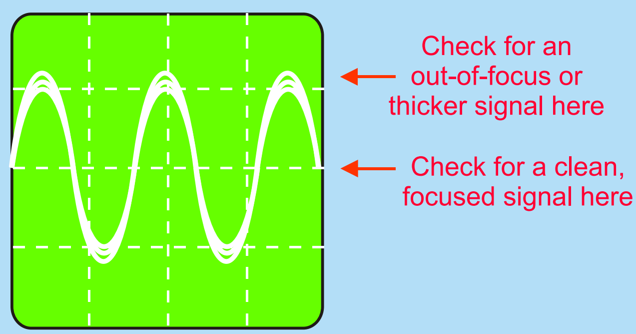
Excessive oscillator phase noise in receivers can cause IMD products and noise in the audio range at the output of the mixer(s), including the product detector. In a transmitter, excessive oscillator phase noise will put power in the close-in sidebands of your carrier, not only wasted power for lower transmitter efficiency, but may produce strange sounds (buzzing or chirping) to the receiving station. A few causes of phase noise are excessive current in the oscillator transistor, low-Q coil(s), high dissipation in the tuning caps or poor power supply filtering at the oscillator frequency.

AM (Amplitude) Noise

Another oscillator problem may be AM noise, or amplitude modulated noise. It is an opposite effect on a scope when displaying the oscillator output — the sine wave appears out-of-focus or thicker at the peaks, and in-focus elsewhere as shown in **Fig. 18**.

If you detect AM noise, slow down the scope's sweep rate to the audio frequencies or slower to see if you can notice a lower frequency component. A common cause of AM oscillator noise is 60 Hz from the power mains leaking into the circuits. This is particularly true if using a power supply off of 120v 60 Hz, or sometimes it can be due to the AC lighting above your head! If the AM noise seems to be at the same frequency as the audio output tone, it means audio is getting into the Vcc bus, likely due to poor bypass filtering at the audio amplifier stages (particular if using an LM386 or similar).

Fig. 18 – Checking for AM Oscillator Noise



If you can't find a low frequency component, the AM noise may be random, which may indicate poor voltage regulation, a noisy voltage regulator, or perhaps a circuit in VHF oscillation. If the AM noise seems to occur on key-down only on a transmitter, the transmit current may be loading the power supply, the voltage regulator is under-rated, or just simply loading the oscillator. In the case of loading the power supply or regulator(s), perhaps a separate voltage regulator or zener circuit should be used, dedicated for the oscillator(s). In the case of transmit loading, adding a buffer amplifier or emitter follower to isolate the load from the oscillator may help.

Much of this can be diagnosed also with the scope, by looking at the AC ripple on the DC power lines. You should have less than 50mV of any AC component on the 8-12v DC wiring, whether 60Hz, audio or RF. If >50mV, then additional low or high frequency filtering on the DC power is needed.

Monitoring Transmitter RF Output

RF Power (in watts) is E^2/R, where E is in rms and R=50 . The voltage displayed on the scope (peak-to-peak) must be converted to rms by Erms=.707(Epp/2). To measure properly, the transmitter should be on a 50 dummy load using the normal hi-Z scope input. If your scope has a selectable "50 "input, it can be the transmitter dummy load directly, providing it can tolerate the 50Vpp input. (Always know what the maximum p-p input voltage your oscope will tolerate. It is often stated on your scope at the vertical channel inputs. 50Vpp to 100Vpp are typical).

Measuring Transmitter RF Output Power

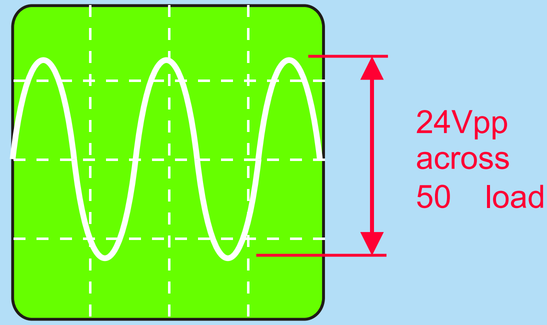
Figure 19 shows how you can use an oscilloscope to fairly accurately measure output power from a low power transmitter (generally 10W or less with a 1X probe and 20-30W with a 10X probe). Connect transmitter output to a 50 dummy load. Connect the scope lead to the transmitter output (after the low pass filters) or directly to the dummy load. Do not connect the scope leads to the collector or drain of the final PA transistor. The displayed voltage in this case will be erroneous.

In the example, the output transmit voltage across the dummy load measures 24Vpp. Convert this voltage to Vrms, then use the equation (Vrms squared divided by the load resistance) to calculate the power in watts. In the example, 24Vpp, the output power is 1.4 watts. A 5W QRP transmitter should produce about 45Vpp.

The accuracy of your power measurements depend upon the condition of your oscilloscope:

1) Ensure your scope's vertical sensitivity (volts/division) is properly calibrated (see Part I)
2) Ensure your vertical sensitivity is properly calibrated with the 1X or 10X probe you are using.
3) Ensure that the transmitter frequency is well within the bandwidth of your scope. A 100 MHz scope should give reliable readings on all HF bands. A 50 MHz scope should be reliable on all HF bands except slight errors at 28MHz.

Fig. 19 –Oscilloscope as a Power Meter



1. Measure output voltage. 24Vpp
2. Convert Vpp to Vrms

   Vrms=.707(Vpp/2) 8.5Vrms

3. Calculate power in watts

$$\frac{Vrms^2}{R} = \frac{8.5v^2}{50} = 1.4W$$

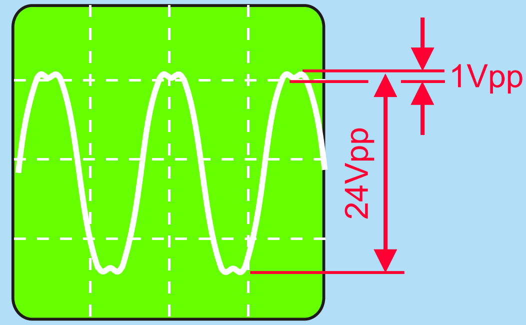
Checking Transmitter Purity

Phase Noise of the transmitter is measured identically to the phase noise checks on page 2–3. With the scope properly triggered and focused, you are looking for an out-of-focus "fuzziness" around zero crossing. If it appears phase noise exists, the fault is generally at the beginning of the transmit chain. That is, seldom does the PA transistor add phase noise; it's merely amplifying what it is given. Phase noise on the transmitter output is more likely due to the transmit oscillator, or the transmit mixer if used.

Harmonic Power can also be detected on a scope while looking at the transmitter RF output power. In **Fig. 20**, notice the "dips" or the two "peaks" on the top and bottom of each sine wave. This is caused by excessive 2nd harmonic output power. The rule-of-thumb is – if you can see any 2nd harmonic power (a dip or flattening at the peaks), then you are right at or exceeding the –30dBc FCC harmonic specification. A clean sine wave implies FCC compliance, providing the 2nd harmonic is within your scope's bandwidth. Obviously, a spectrum analyzer should be used for accurate harmonic evaluation, but a scope can be used to indicate if you have a problem. If you build your own transmitter, it is your responsibility to ensure it is compliant. An approximate method of estimating 2nd harmonic attenuation is shown.

–30dBc means the 2nd harmonic power is 1/1000th of the fundamental power. For a 5W transmitter, this means the 2nd harmonic power should be 5mW or less, or about 1Vpp. In displaying a 5W signal on a scope (45Vpp), it would be difficult to resolve much less than a 1Vpp dip or ripple.

Fig. 20 –Checking 2nd Harmonic Power



1. Measure output voltage. 24Vpp
2. Measure ripple voltage. 1Vpp
3. Calculate dBc of 2nd harmonic ripple

$$20\log\frac{V2}{V1} = 20\log\frac{1v}{24v} = –27.6\text{ dBc}$$

or, not quite FCC compliant!

Conclusion. This concludes the NA5N "Handiman's Guide to Oscilloscopes." Hopefully, it has helped you to understand your oscilloscope to make simple measurements, and with some practice, perform the more advanced measurements discussed. An oscilloscope is a very powerful tool that is invaluable on the homebrewer's workbench. If there is a particular measurement you feel I omitted, please let me know and I will add it when time permits.

73, Paul Harden, NA5N (na5n@zianet.com or pharden@nrao.edu)

THE HANDYMAN'S GUIDE TO OSCILLOSCOPES (Part 2 of 2)

by Paul Harden, NA5N

Making some advanced measurements with your Oscilloscope

Print as .pdf file
4 pages
8½ x 11 or A4

In Part 1, oscilloscope operation was covered for making basic voltage, time and frequency measurements. In this part, we'll continue with some more advanced uses of a scope, and in particular, how to use a scope for testing and troubleshooting ham radio QRP transceivers in the homebrewer's workshop.

Receiver Filter Bandwidth.

This procedure uses a scope (a DVM can be used with less accuracy) for determining the overall filter bandwidth (or selectivity) of a receiver. It is basically measured by plotting output voltage vs. audio frequency to construct a picture of the filter response.

Connect scope to the receiver audio output (speaker or phone jack); measurement will be based on peak-to-peak voltages (Vpp) on a scope, or rms voltage (Vrms) on a DVM.

Using a signal generator, set the frequency for the band of interest on your radio. For example, on a general coverage shortwave receiver, you might set it for 10 MHz (top end of the 31M band), or perhaps to 7.040 MHz on a 40M ham radio receiver/transceiver. Tune the receiver to the signal generator signal. If you don't have a signal generator, you can also tune to a steady carrier or station to produce a hetrodyne audio "pitch." Tune in the signal to the pitch that causes the maximum peak-to-peak display. Adjust the scope and volume control to produce a 2Vpp display (4 divisions). This is the peak response of the overall filtering stages as shown in **Fig. 13**.

Now determine the audio frequency at this peak response by measuring the time period between cycles and covert to frequency. In the example to the right, the period of one cycle is 1.7mS, which is an audio tone of 750Hz (1/.0017sec). A frequency counter on the output can also be used.

Next, tune the receiver such that the sidetone pitch goes UP in frequency and the peak-to-peak signal will decrease in magnitude. Tune to the point where the signal is exactly 1Vpp on the scope. See **Fig. 12**.

This is the –6dB point of the high end of the filter (20log 1v/2v =–6dB). Determine the frequency of the audio pitch as before. In the example, this is 1100 Hz. Record the data.

From these two data points, the –6dB bandwidth can be estimated. The bandwidth from the filter peak (750 Hz) to the –6dB point (1100 Hz) is 350 Hz. The bandwidth (BW) between the two –6dB points is usually twice this value, or 700 Hz. A filter with a –6dB BW of 700Hz is a mediocre filter for CW reception, and way too narrow for SSB or AM.

Of course you can determine the exact –6dB BW by tuning the receiver back to the 2Vpp peak response, and continue tuning DOWNward in frequency until the audio is again exactly 1Vpp. Determine this frequency and record. In this example, it should occur around 400 Hz if the filter shape is symmetrical.

Plot these three data points on a sheet of graph paper as shown in **Fig. 15** to construct the filter shape. Return to the upper –6dB point (1100Hz in the example) and continue tuning upwards in audio pitch, recording the frequency at 0.5v (–12 dB), 0.25v (–18 dB), 125mV (–24 dB), etc. Everytime you "halve the voltage," it is a 6 dB change. The more points you collect, the more accurate your filter response plot will be.

Fig. 13 – Displaying Filter Peak Response

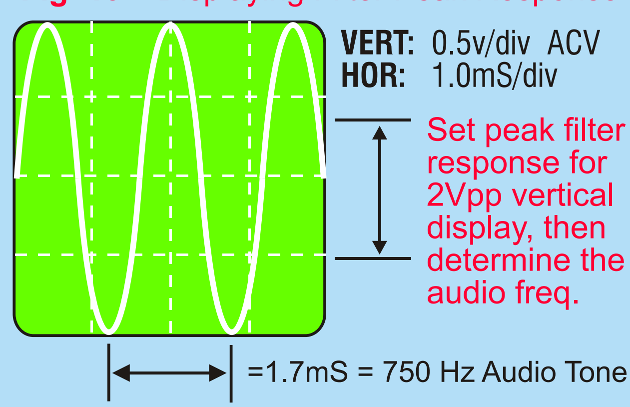
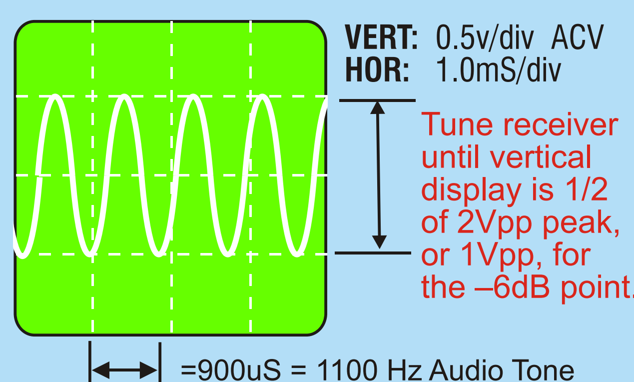
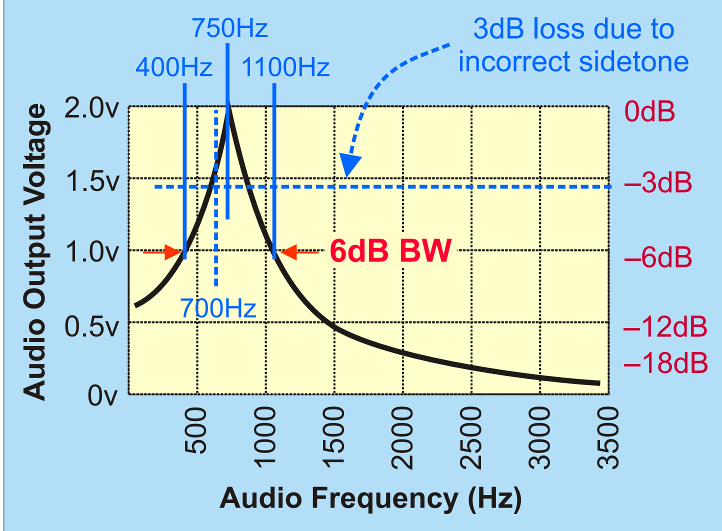


Fig. 14 – Displaying –6dB Frequency



Of interest to proper rig alignment is to repeat the above using the output of the product detector. To maximize the effectiveness of the filtering, the receive offset frequency set by the BFO should be adjusted to the same frequency as the peak frequency response of the audio. In this example, with the peak audio response occuring at 750Hz, if your BFO is set for a sidetone frequency of 700 Hz, you are loosing 2–3 dB, since this is in your filter skirt. This is shown on the response plot in **Fig. 15** by the dashed lines. By adjusting your BFO for a sidetone frequency of 750 Hz, you will pick up 3-4dB of overall gain in your receiver, plus increase the selectivity a bit as well. Why? Because nearby stations, such as one at 800–900Hz tone, could actually be louder than the 700Hz tone signal you are trying to copy, since the gain of the receiver is greater at those tones than at 700Hz, as shown in the plot.

Fig. 15 – Plotting Audio Response



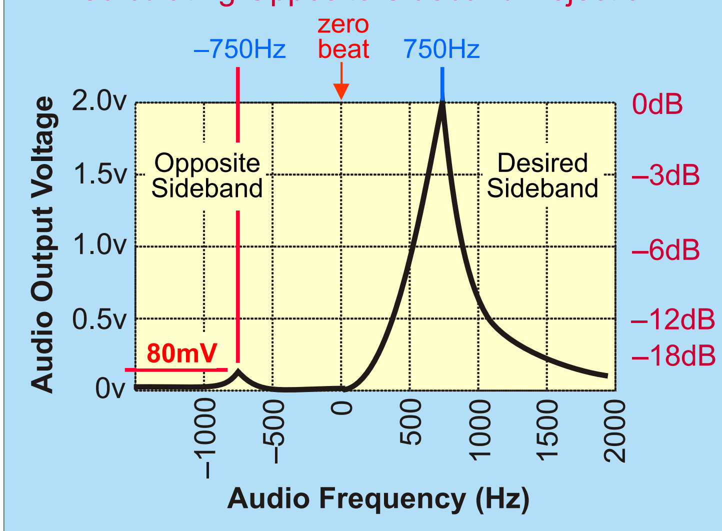
Opposite Sideband Rejection

A superhet receiver is supposed to pass just one sideband and reject the other. Poor opposite sideband rejection could indicate the crystals in your IF filter are not well matched or other problems. It is measured almost identical to plotting the filter response just described. First, you tune the receiver to the test signal to find the peak response frequency, or 750Hz in this example. Set the scope display for 2Vpp. Now tune downward in audio pitch, passing zero-beat, and continue tuning and you should hear the test signal, much weaker, now rising again in tone. This is the *opposite sideband*. Measure the peak-to-peak voltage, if you can. For example, say it is 80mVpp, as shown in **Fig. 16**. Calculate the opposite sideband rejection by:

$$\text{rejection} = 20\log\frac{80\text{mV}}{2.0\text{v}} = \frac{80\text{mV}}{2000\text{mV}} = -28\text{dB}$$

If you can't hear the opposite sideband, then obviously you have excellent filter rejection. If you can just barely hear it, you may have to increase the sensitivity of your scope (set vertical gain to 20 or 50 mV/div). In this example, –28dB rejection of the opposite sideband is quite good. A –30dB rejection means the opposite sideband is only 1/1000th of the desired sideband, a very suitable attenuation of the opposite sideband.

Fig. 16
Calculating Opposite Sideband Rejection



These tests are important to perform on your rig for documenting it's current performance, and repeated periodically to detect unfavorable changes or for troubleshooting when a problem is evident. For homebrewing, these tests can allow you to evaluate different circuits or when experimenting with different components or part values.

Oscillator Phase Noise

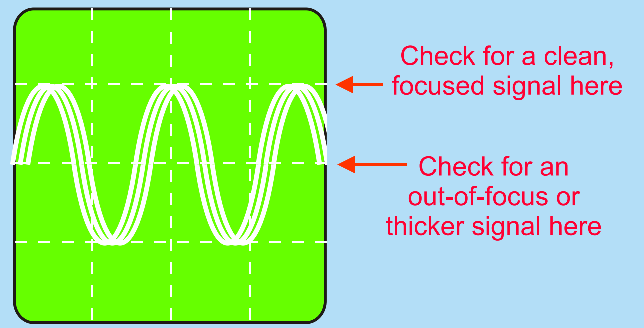
When homebrewing a basic oscillator circuit, such as a VFO, looking at the oscillator output on a scope can reveal several problems. One is to check for excessive phase noise. Phase noise is small variations of the oscillator frequency that causes power in the close-in sidebands, usually measured on laboratory equipment within 100KHz, or even within 10 KHz.

To check for oscillator phase noise, connect the oscilloscope to the oscillator output, loading the output of the oscillator as little possible. Most scopes have sufficiently high input impedances where this shouldn't be a problem, but some cheaper scopes can load an oscillator circuit. If you suspect your scope is loading the oscillator, couple the scope to the circuit with a small value capacitor, less than 20pF.

Display 2–3 cycles of the oscillator output as shown on the scope display shown in **Fig. 17**. Properly focus the scope and carefully observe if the waveform appears in focus at the peaks, but slightly out-of-focus at the zero-crossing points, that is, on the rising and falling edges of the sine wave.

If it appears out-of-focus, this is excessive phase noise jittering the signal and "smearing" the waveform along the time (horizontal) axis. Extreme phase noise may show 2-3 sine waves very close to each other, as shown in the exagerated waveform to the right — assuming you have your scope properly triggered.

Fig. 17 – Checking Oscillator Phase Noise



Phase noise is random, instantaneous changes in the oscillator frequency that smears the display. If you can see this on a scope, the phase noise is excessive! If you can't see it, it doesn't mean the oscillator has no phase noise (all oscillators have some phase noise), it just means it is not excessive enough to see on a scope. A scope is not a good instrument for checking phase noise, but for homebrew circuits, it is a check to ensure you do not have a serious oscillator problem.

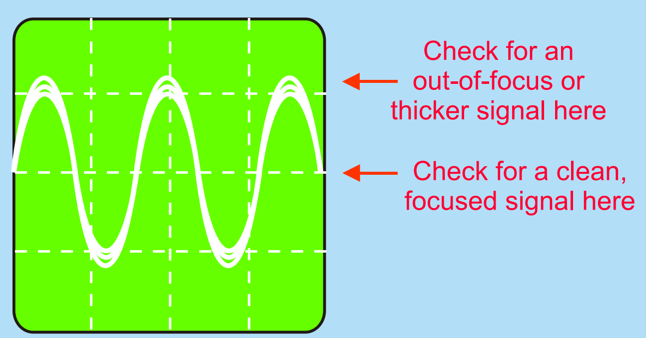
Excessive oscillator phase noise in receivers can cause IMD products and noise in the audio range at the output of the mixer(s), including the product detector. In a transmitter, excessive oscillator phase noise will put power in the close-in sidebands of your carrier, not only wasted power for lower transmitter efficiency, but may produce strange sounds (buzzing or chirping) to the receiving station. A few causes of phase noise are excessive current in the oscillator transistor, low-Q coil(s), high dissipation in the tuning caps or poor power supply filtering at the oscillator frequency.

AM (Amplitude) Noise

Another oscillator problem may be AM noise, or amplitude modulated noise. It is an opposite effect on a scope when displaying the oscillator output — the sine wave appears out-of-focus or thicker at the peaks, and in-focus elsewhere as shown in **Fig. 18**.

If you detect AM noise, slow down the scope's sweep rate to the audio frequencies or slower to see if you can notice a lower frequency component. A common cause of AM oscillator noise is 60 Hz from the power mains leaking into the circuits. This is particularly true if using a power supply off of 120v 60 Hz, or sometimes it can be due to the AC lighting above your head! If the AM noise seems to be at the same frequency as the audio output tone, it means audio is getting into the Vcc bus, likely due to poor bypass filtering at the audio amplifier stages (particular if using an LM386 or similar).

Fig. 18 – Checking for AM Oscillator Noise



If you can't find a low frequency component, the AM noise may be random, which may indicate poor voltage regulation, a noisy voltage regulator, or perhaps a circuit in VHF oscillation. If the AM noise seems to occur on key-down only on a transmitter, the transmit current may be loading the power supply, the voltage regulator is under-rated, or just simply loading the oscillator. In the case of loading the power supply or regulator(s), perhaps a separate voltage regulator or zener circuit should be used, dedicated for the oscillator(s). In the case of transmit loading, adding a buffer amplifier or emitter follower to isolate the load from the oscillator may help.

Much of this can be diagnosed also with the scope, by looking at the AC ripple on the DC power lines. You should have less than 50mV of any AC component on the 8-12v DC wiring, whether 60Hz, audio or RF. If >50mV, then additional low or high frequency filtering on the DC power is needed.

Monitoring Transmitter RF Output

RF Power (in watts) is E^2/R, where E is in rms and R=50 . The voltage displayed on the scope (peak-to-peak) must be converted to rms by Erms=.707(Epp/2). To measure properly, the transmitter should be on a 50 dummy load using the normal hi-Z scope input. If your scope has a selectable "50 "input, it can be the transmitter dummy load directly, providing it can tolerate the 50Vpp input. (Always know what the maximum p-p input voltage your oscope will tolerate. It is often stated on your scope at the vertical channel inputs. 50Vpp to 100Vpp are typical).

Measuring Transmitter RF Output Power

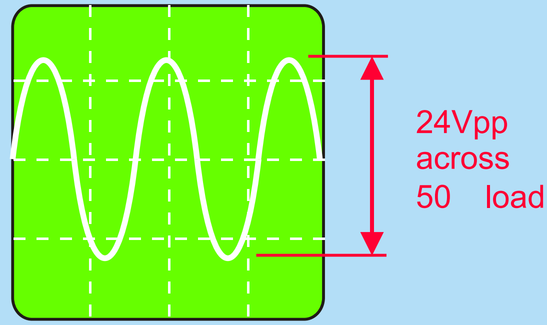
Figure 19 shows how you can use an oscilloscope to fairly accurately measure output power from a low power transmitter (generally 10W or less with a 1X probe and 20-30W with a 10X probe). Connect transmitter output to a 50 dummy load. Connect the scope lead to the transmitter output (after the low pass filters) or directly to the dummy load. Do not connect the scope leads to the collector or drain of the final PA transistor. The displayed voltage in this case will be erroneous.

In the example, the output transmit voltage across the dummy load measures 24Vpp. Convert this voltage to Vrms, then use the equation (Vrms squared divided by the load resistance) to calculate the power in watts. In the example, 24Vpp, the output power is 1.4 watts. A 5W QRP transmitter should produce about 45Vpp.

The accuracy of your power measurements depend upon the condition of your oscilloscope:

1) Ensure your scope's vertical sensitivity (volts/division) is properly calibrated (see Part I)
2) Ensure your vertical sensitivity is properly calibrated with the 1X or 10X probe you are using.
3) Ensure that the transmitter frequency is well within the bandwidth of your scope. A 100 MHz scope should give reliable readings on all HF bands. A 50 MHz scope should be reliable on all HF bands except slight errors at 28MHz.

Fig. 19 –Oscilloscope as a Power Meter



1. Measure output voltage. 24Vpp
2. Convert Vpp to Vrms

   Vrms=.707(Vpp/2) 8.5Vrms
3. Calculate power in watts

$$\frac{Vrms^2}{R} = \frac{8.5v^2}{50} = 1.4W$$

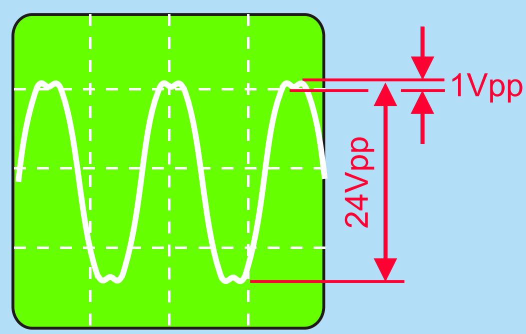
Checking Transmitter Purity

Phase Noise of the transmitter is measured identically to the phase noise checks on page 2–3. With the scope properly triggered and focused, you are looking for an out-of-focus "fuzziness" around zero crossing. If it appears phase noise exists, the fault is generally at the beginning of the transmit chain. That is, seldom does the PA transistor add phase noise; it's merely amplifying what it is given. Phase noise on the transmitter output is more likely due to the transmit oscillator, or the transmit mixer if used.

Harmonic Power can also be detected on a scope while looking at the transmitter RF output power. In **Fig. 20**, notice the "dips" or the two "peaks" on the top and bottom of each sine wave. This is caused by excessive 2nd harmonic output power. The rule-of-thumb is – if you can see any 2nd harmonic power (a dip or flattening at the peaks), then you are right at or exceeding the –30dBc FCC harmonic specification. A clean sine wave implies FCC compliance, providing the 2nd harmonic is within your scope's bandwidth. Obviously, a spectrum analyzer should be used for accurate harmonic evaluation, but a scope can be used to indicate if you have a problem. If you build your own transmitter, it is your responsibility to ensure it is compliant. An approximate method of estimating 2nd harmonic attenuation is shown.

–30dBc means the 2nd harmonic power is 1/1000th of the fundamental power. For a 5W transmitter, this means the 2nd harmonic power should be 5mW or less, or about 1Vpp. In displaying a 5W signal on a scope (45Vpp), it would be difficult to resolve much less than a 1Vpp dip or ripple.

Fig. 20 –Checking 2nd Harmonic Power



1. Measure output voltage. 24Vpp
2. Measure ripple voltage. 1Vpp
3. Calculate dBc of 2nd harmonic ripple

$$20\log\frac{V2}{V1} = 20\log\frac{1v}{24v} = -27.6\ \text{dBc}$$

or, not quite FCC compliant!

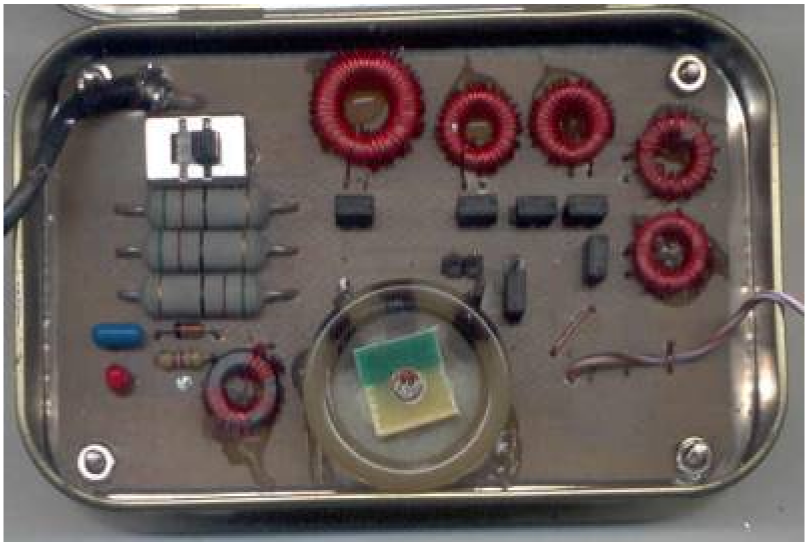
Conclusion. This concludes the NA5N "Handiman's Guide to Oscilloscopes." Hopefully, it has helped you to understand your oscilloscope to make simple measurements, and with some practice, perform the more advanced measurements discussed. An oscilloscope is a very powerful tool that is invaluable on the homebrewer's workbench. If there is a particular measurement you feel I omitted, please let me know and I will add it when time permits.

73, Paul Harden, NA5N (na5n@zianet.com or pharden@nrao.edu)

ALT - Altoids L Tuner

NOTE: a kit version of this tuner is available from qrpkits.com

Versatile L tuner for end feed wire antennas, fits in an Altoids tin. A compact and light weight system for use in the field by campers and backpackers.



A basic resistive bridge SWR meter with LED indicator is included on the board for adjusting the tuner. The L tuner is a series L, shunt C configuration. The L consists of five toroids, with the values 8 uH, 4 uH, 2 uH, 1 uH and 0.5 uH. Shunt plugs allow shorting out each inductor, so a wide range of inductance values can be achieved, from 0.5 uH to 15.5 uH.

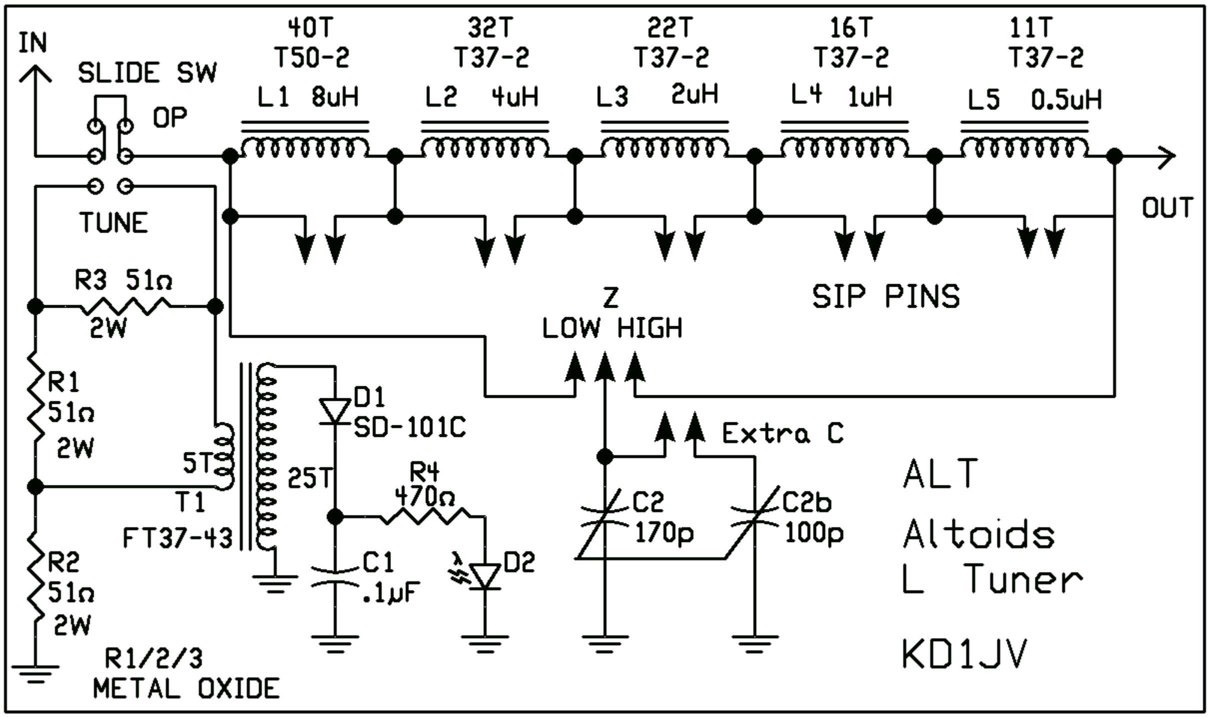
The polyvariable cap was salvaged from a cheap AM/FM radio, which is about the only source for these things these days. There are two sections, one ranges from a few pfd to 100 pfd, the other up to 170 pfd. The higher range section is normally used for tuning, though the other section can be paralleled if extra capacitance is needed. The cap can also be switched from across the output (wire) side of the L, (for high impedance loads) or across the input or transmitter side, for low impedance loads. (Note. matching to low impedance loads doesn't seem to work!)

The RG-174 coax to connect to the rig is attached to the board, as is a short length of wire to go to the antenna wire spool. These wires do not come out holes drilled in the tin, so that they can be stored inside the tin. The knob for the tuning cap is made from a large shirt button.

The frequency range of the tuner is 40M and up to at least 15M. The best results, antenna length should be close to, but not exactly 1/2 wave long on the lowest frequency. For example, a 51 foot wire can be matched on 40, 20 and 15. A 45 foot length of wire matches on 40, 30 and 20 (and maybe on 15), though the match on 40 is not quite exact. Using a counterpoise of 16 feet is recommended.

Its a good idea to figure out the tuner settings using an antenna analyzer first, such as the KD1JV Tenna Dipper, one of the MFJ units or similar. Note the settings for each band for future reference. Use the built in resistive SWR bridge for fine tuning out in the field.

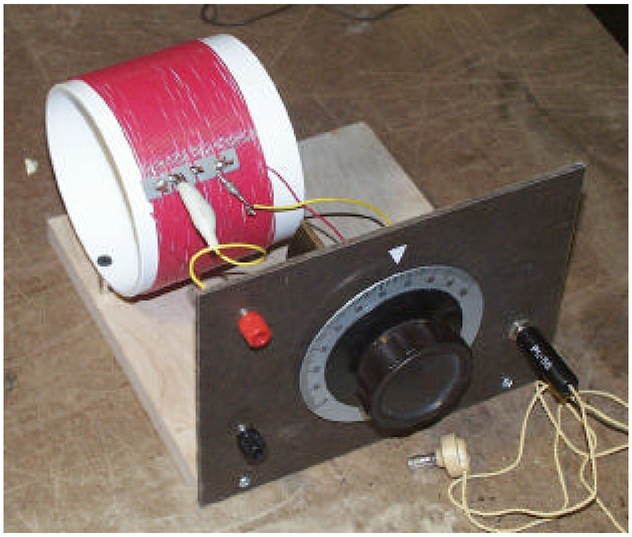
This tuner is designed to match the high impedance of 1/2 wave, end feed antennas. To match low impedance antennas, such as wires less than 1/4 wave, much smaller inductances and much higher capacitances need to be used.



A Pretty Good Crystal Set

By Al Klase, N3FRQ, http://www.skywaves.ar88.net/

OK! It's time to build a crystal set. This time it's going to be a good one.



Countless millions of crystal radios have been built over the last 100 years, but the performance of most of these leaves a lot to be desired. The design of this radio goes back to about 1990 when I was a den leader for my son's Cub-Scout pack. I wanted the guys to have the experience of listening to a radio they had built with their own hands. However, we were in the deep suburbs of Philadelphia (actually half way to Reading). There were no strong local stations, so an average crystal set combined with the sort of makeshift antenna most families would erect, wasn't going to get the job done. The result was the Den Two Crystal Radio. (See "Crystal Set Projects," The Xtal Set Society, 1997.) This radio was based on a spider-web coil that 10-year-old hands could wind with a little supervision. It was sensitive enough to hear distant sky-wave stations at night, and selective enough that you could usually listen to just one station. Seven were constructed and at least six of those went into service at home. Everyone was duly impressed. We even had reports of hearing Radio Japan! (That was from Ontario, however.) We'll use the same circuit with a better solenoid-style coil.

First, lets deal with the headset. Look around for a traditional pair of 2000-ohm 'phones. That's the DC resistance, they'll have an AC impedance of about 10,000 ohms. Test the 'phones by putting them on your head, holding on to one of the tips and touching the other to an electrical ground such as a water pipe or the screw on an outlet plate. You should hear a click or maybe a hum. If not, they probably won't be sensitive enough for our purposes. Check the DC resistance with an ohm meter, it should be in the range of 1-5 K-ohms. Sometimes the cords are open.

An acceptable alternative to a vintage headset is one of the crystal (ceramic) ear plugs available from Mouser.com for about two bucks. It's best to install a 50-100K resistor in parallel with these 'phones to provide a DC load for the detector to eliminate audio distortion.

Modern low-impedance headsets with a matching transformer might work if you have a lot of signal strength, but most are designed to sacrifice sensitivity for flat frequency response.

Next, comes the detector. Stick to a germanium diode or the base-emitter junction of a germanium transistor for openers. A digital voltmeter in the diode position will indicate the forward voltage drop. Germanium devices will show 0.2-0.3 while

silicon will indicate 0.5-0.7 volts. You can use a modern silicon device, but you'll be giving up a lot of sensitivity. The basic germanium diode is the 1N34A, but the part number doesn't mean much. They vary widely. Dump out the junk box, try them in a radio, and pick the best one. You can move on to mineral detectors and cat's whiskers after you have a working radio.

Now you'll need an antenna, the higher, longer, and more in the open the better. Sixty feet long and forty feet high would be excellent, but wire in the attic will probably suffice, especially if you're a "city mouse." A wire to a hose clamp around a water pipe or a connection to the screw on an outlet plate (AC safety ground) will complete the antenna-ground system.

Now it's time to build the simplest possible radio: Clip-lead the diode across the headset and then connect one side to the antenna and the other side to ground. You should hear something, quite possibly three stations at once.

To make this kludge into a serviceable radio we'll add a tuned "tank" circuit consisting of a coil and a variable capacitor. The target value for the cap is 365 pico-farads (mmF or pF), but a 500 pF unit as found in some of the old battery sets will work nearly as well. You could also use the large half of the two-gang cap from a junked all-American five radio, etc.

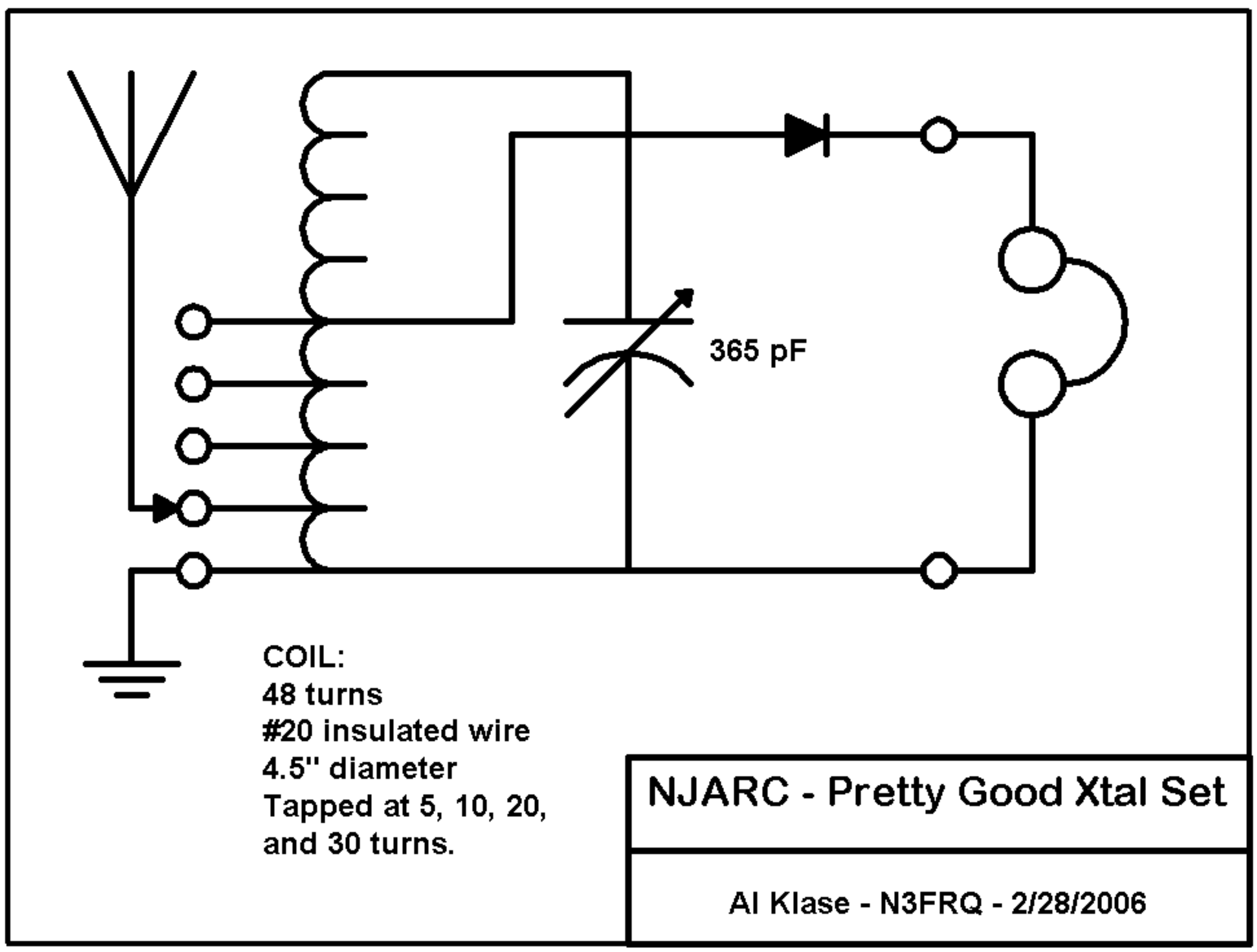
The coil is wound on a 4-inch styrene pipe coupling from the "home center." Wire is generally expensive and hard to buy retail. I've specified #20 insulated bell wire, also from the "home center" because it is easily available. The down side is that it's twisted pair that needs to be unwound, and they make you buy 500 feet, for about 30 bucks, when you only need 85 feet for the project. Any plastic insulated wire between #26 and #20 will do, but you'll probably need to adjust the total number of turns after you get the radio going to cover both ends of the broadcast band. The best option, for maximum performance, is silver-plated Teflon-insulated hook-up wire if you have any in the junk box, but even common vinyl-insulated tinned stranded wire will work all right. Close-wound magnet wire is a bad bet, as eddy currents in the adjacent turns cause considerable loss.

Winding the coil: Tie one end of an 85-foot length of wire to a solid support. Drill two small holes 3/8 of an inch from the end of the coil form. Keep the drill and wire cutters handy. Put a strip of thin cardboard about 3/8 inch wide and 3 inches long in your shirt pocket. Lace the end of the wire into one hole and out the other, leaving about a foot protruding from the form. Grasp the coil form firmly and pull the wire taught against the tied off end. Wind 5 turns on the coil keeping the wrie close-wound and tight. Place the end of the cardboard strip under the 5th turn. Wind four more turns, sneaking them under the strip. Wind the 10th turn over the strip. Continue winding placing the 20th and 30th

turns on top of the cardboard. Wind 18 more turns for a total of 48. Clip the wire leaving about a foot to terminate the coil., drill two more holes in the form, and lace the end of the wire through them.

Use a utility knife to whittle away the insulation where the 5th, 10th, 20th, and 30th turns cross the cardboard. Wrap and solder a piece of bare wire at each of these sites to form the coil taps.

"Beadboard" the radio with clipleads or tack-solder joints to make sure everything works before committing to a physical design. The radio in the picture is built on an 8-inch square piece of ¾" plywood with an 8 x 6-inch front panel of tempered hardboard. Layout is not critical, but keep the coil in the approximate orientation shown so it can be coupled to the antenna tuner to be described in "PGXS – Phase II."



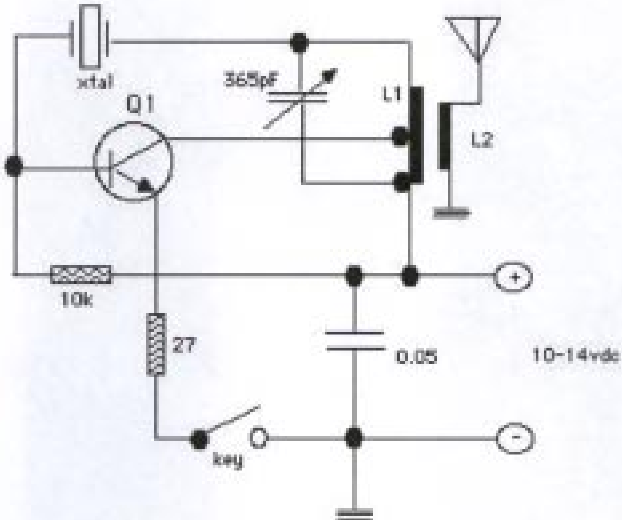
amateur radio license required to operate on the air!

500mW CW TRANSMITTER

Cost estimate: $10

A **very** quick and easy way to get on the air is to build a "Michigan Mighty Mite" CW transmitter for 160, 80, 40 or 30 meters originated by Ed Knoll, W3FQJ and developed by Tom Jurgens, KY8I. It can't get simpler than this! I made my very first QSOs with a 40-meter version (photo). It has very few parts, costs almost nothing, and **it works!**

Output power is about 500 milliwatts with a 12-volt power supply. To operate, attach 50-ohm dummy load or appropriate 50-ohm antenna (do yourself a favor and use a half-wave dipole antenna to avoid tuners and assure good results) and ground, insert crystal and close the key. Adjust the variable capacitor for the cleanest signal that has the most power (compromise).That's it! You're on the air, and can confirm that it's working with field strength meter. Power output can be figured with a common multitester by using a very simple wattmeter circuit.



Q1:
2N3053, 2N2222, SK3265 or similar inexpensive general-purpose NPN transistor. I use a plastic-case transistor that came in a bargain-pack from Radio Shack - works fine. Use heat sink - try an alligator clip if you don't have a heat sink handy.

TANK COIL:
use a 1.25" diameter form (35mm film canister, pill bottle, etc.) and #20 - #22 AWG enameled ("magnet") wire. To make tap, wind L1 to the "tapped at" number of turns (see table below). Make a loop about 1 inch long, twist it a few times and finish winding. Sand the insulation off the end of the loop. This is your tap. After winding L1, wrap it with a thin layer of masking tape and wind L2 on top of the tape **in the same direction** as L1. Secure L2 with more tape and finish by sanding insulation off remaining leads.

L1:	L2:
(primary/collector windings)	(secondary/antenna windings)
160m--60 turns, tapped at 20	160m-- 8 turns
80m--45 turns, tapped at 15	80m---6 turns
40m--21 turns, tapped at 7	40m---4 turns

```
30m--15 turns, tapped at 6          30m---4 turns
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XTAL: fundamental-mode crystal for desired frequency.
About that variable capacitor - the unit in the photo is a discontinued item from Radio Shack, but NO PROBLEM - salvage one from an old transistor AM Radio or try a trimmer capacitor. Of course, a fullsize variable will work - but it will also be bigger than the rest of the transmitter! Tracking down variable capacitors at a good price is a noble challenge and part of the game.

ANTENNAS FOR LOW POWER APPLICATIONS

By Kent Smith

Introduction:

There seems to be little information on compact antenna design for the low power wireless field. Good antenna design is required to realize good range performance. A good antenna requires it to be the right type for the application. It also must be matched and tuned to the transmitter and receiver. To get the best results, a designer should have an idea about how the antenna works, and what the important design considerations are. This paper should help to achieve effective antenna design.

Terminology:

Wavelength - Important for determination of antenna length, this is the distance that the radio wave travels during one complete cycle of the wave. This length is inversely proportional to the frequency and may be calculated by: wavelength in cm = 30,000 / frequency in MHz.

Groundplane - A solid conductive area that is an important part of RF design techniques. These are usually used in transmitter and receiver circuits. An example is where most of the traces will be routed on the topside of the board, and the bottom will be a mostly solid copper area. The groundplane helps to reduce stray reactances and radiation. Of course, the antenna line needs to run away from the groundplane.

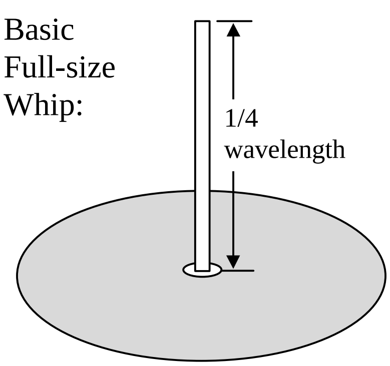
dB (decibel) - A logarithmic scale used to show power gain or loss in an RF circuit. +3 dB is twice the power, while -3 dB is one half. It takes 6 dB to double or halve the radiating distance, due to the inverse square law.

The Basic Antenna and how it Works.

An antenna can be defined as any wire, or conductor, that carries a pulsing or alternating current. Such a current will generate an electromagnetic field around the wire and that field will pulse and vary as the electric current does. If another wire is placed nearby, the electromagnetic field lines that cross this wire will induce an electric current that is a copy of the original current, only weaker. If the wire is relatively long, in terms of wavelength, it will radiate much of that field over long distances.

The simplest antenna is the "whip". This is a quarter wavelength wire that stands above a groundplane. The most common examples are found on automobiles and are used for broadcast radio, CB and amateur radio, and even for cellular phones. This design goes back to the 1890's when Marconi set out to prove that radio signals could travel long distances. To be successful, he had to stretch a long wire above the ground. Due to the low frequencies, thus a long wavelength, the wire had to be long. He also found that the wire worked better when it was high above ground.

Basic Full-size Whip:



All antennas, like any electronic component, have at least two connection points. In the case of the whip, there must be a connection to a ground, even if the groundplane area is nothing more than circuit traces and a battery. The whip and groundplane combine to form a complete circuit. The electromagnetic field is set up between the whip and the ground plane, with current flowing through the field, thus completing the circuit. Ideally, a groundplane should spread out at least a quarter wavelength, or more, around the base of the whip. The groundplane can be made smaller, but it will affect the performance of the whip antenna. The groundplane area must be considered when designing an antenna.

A quarter-wave whip is not a compact antenna. At 1 MHz, in the AM Broadcast band, one quarter of the wavelength is about 246 feet, or 75 meters. At 100 MHz, in the FM Broadcast Band, it is nearly 30 inches (75 cm). This dimension continues to shrink at higher frequencies, being nearly 3 inches (7.5 cm) at 1000 MHz. A simple formula for the quarter-wave (in cm) is: 7500 divided by the freq. (in MHz), or for inches: 2952 / freq. (in MHz). This formula is only a starting point since the length may actually be shorter if: the whip is overly thick or wide, has any kind of coating, or is not fed close to ground. It may need to be longer if the ground plane is too small.

The length of the antenna should be measured from the point where it leaves close proximity to ground, or from the transmitter output. If a whip is mounted on a box, and connected to the transmitter with plain wire, that wire becomes part of the antenna! To avoid mistuning the antenna, coaxial cable should be used to connect to an external antenna. On a circuit board, the equivalent to coax is a trace that runs over a groundplane (groundplane on the backside). The above are examples of transmission lines, whose purpose is to efficiently transfer power from one place to another with minimum loss. Do not try to run an antenna line too close to ground, it becomes more of a transmission line than an antenna. Fortunately for those who need a small remote device, a transmission line left open-ended will radiate some energy.

Antenna Characteristics:

Gain:
An antenna that radiates poorly has low “gain”. Antenna gain is a measure of how strongly the antenna radiates compared to a reference antenna, such as a dipole. A dipole is similar to a whip, but the groundplane is replaced with another quarter-wave wire. Overall performance is about the same. An antenna that is 6 dB less than a dipole is -6 dBd. This antenna would offer one half the range, or distance, of the dipole. Compact antennas are often less efficient than a dipole, and therefore, tend to have negative gain.

Radiation Pattern:
Radiation is maximum when broadside, or perpendicular to a wire, so a vertical whip is ideal for communication in any direction except straight up. The radiation “pattern”, perpendicular to the whip, can be described as omnidirectional. There is a "null", or signal minimum, at the end of the whip. With a less than ideal antenna, such as a bent or tilted whip, this null may move and partly disappear. It is important to know the radiation pattern of the antenna, in order to insure that a null is not present in the desired direction of communication.

Polarization:
It is important that other antennas in the same communication system be oriented in the same way, that is, have the same polarization. A horizontally polarized antenna will not usually communicate very effectively with a vertical whip. In the real environment, metal objects and the ground will cause reflections, and may cause both horizontal and vertical polarized signals to be present.

Impedance:
Another important consideration is how well a transmitter can transfer power into an antenna. If the antenna tuning circuit on a transmitter (or receiver) is designed for a 50 ohm load, the antenna should, of course, have an impedance near 50 ohms for best results. A whip over a flat groundplane has an impedance near 35 ohms, which is close enough. The impedance changes if the whip is mistuned or bent down, or if a hand or other object is placed close to it. The impedance becomes lower as the antenna is bent closer to ground. When the whip is tilted 45 degrees, the impedance is less than 20 ohms. When the whip is bent horizontal to

one-tenth of a wavelength above ground, the impedance approaches 10 ohms. The resulting impedance mismatch, a 5:1 ratio (VSWR) will contribute an additional loss of 2.6 dB.

Printed Circuit Whip, or "Stub"

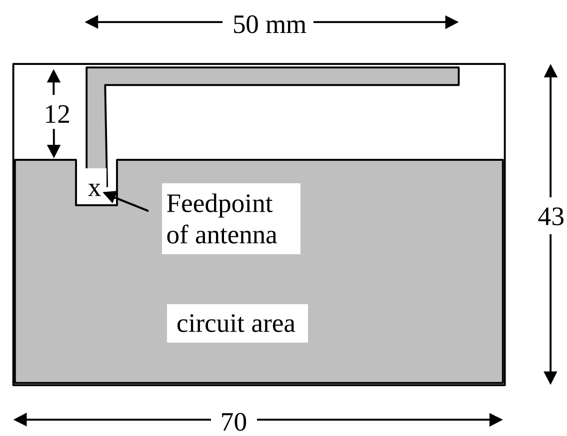
The whip can be made as a trace on a printed circuit board (PCB). This is very practical at frequencies over 800 MHz. At lower frequencies, a full size whip may be too long, even when wrapped around a few corners. The length of the whip should be 10 to 20% shorter than the calculation, depending on the dielectric and the thickness of the board. In most cases, 15% shorter is close enough. If the unit is to be hand held, the antenna can be made a little shorter, to compensate for the effect of the hand.

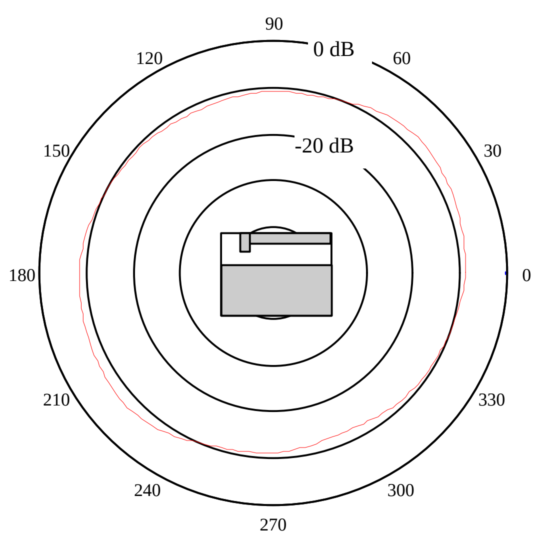
At 916 MHz, a trace that is 2.25 inches (57 mm) long will provide a reasonable impedance when hand effects are included. Keep the antenna trace away from other circuitry and ground, a quarter of an inch (6 mm), or more. Non-ground circuit traces may be seen by the antenna as part of the ground system, and RF voltages can be induced on nearby traces.

Our sample PCB Stub is shown in the drawing at right. The overall size of the board and ground is not critical. The radiation pattern is omnidirectional, with a gain of -8 to -12 dBd, when the board is horizontal. Polarization is horizontal. If the whip did not run parallel to ground, the gain would be higher, however, two sharp nulls would be present. If the board were oriented vertically, with the antenna above the groundplane, the polarization would be vertical. The antenna would have an omnidirectional pattern with -8 dBd of gain.

Printed Open Stub:

916.5 MHz





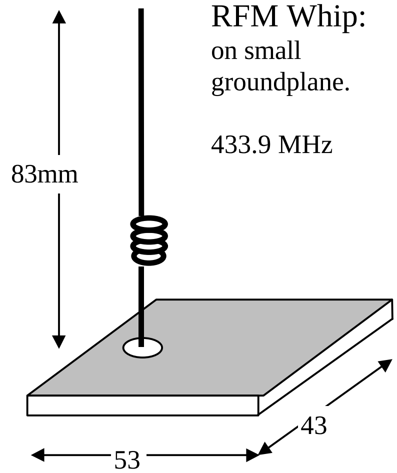
Radiation Pattern of Open Stub Antenna
(916.5 MHz)

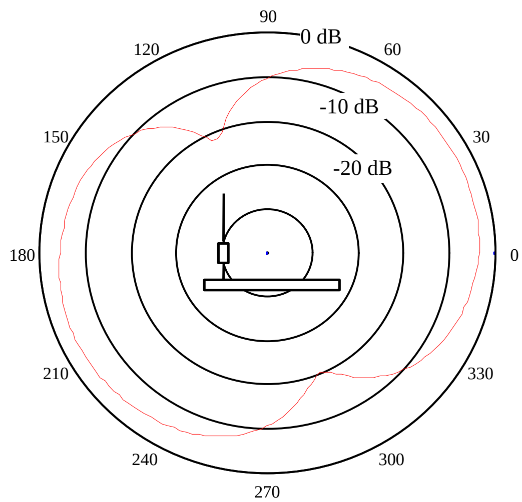
Compact Antennas:

The Short Whip

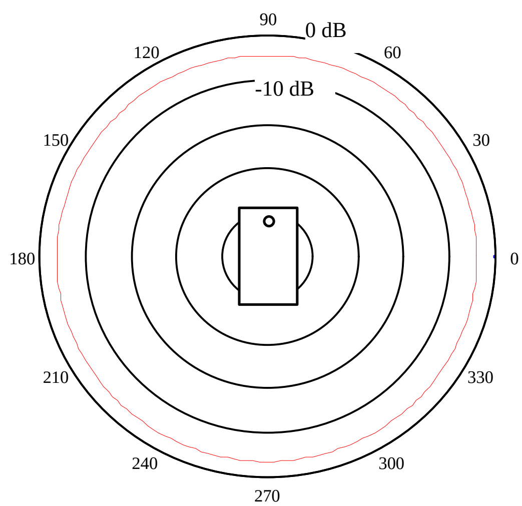
A simple alternative to the whip is to make it shorter than a quarter wavelength and add an inductor near the base of the whip to compensate for the resulting capacitive reactance. The inductor can be made by coiling up part of the whip itself. This type of antenna can have performance nearly equal to that of a full size whip.

RFM uses such a design for the wire antennas that are supplied with our demonstration boards. Details of the design can be found in the HX/RX portion of the Product Data Book. The RFM short whip is optimized for under-sized groundplanes. When tested on the edge of a small board, gain was only 3 to 4 dB less than a full sized whip and groundplane.





Loaded Whip Antenna (434 MHz)



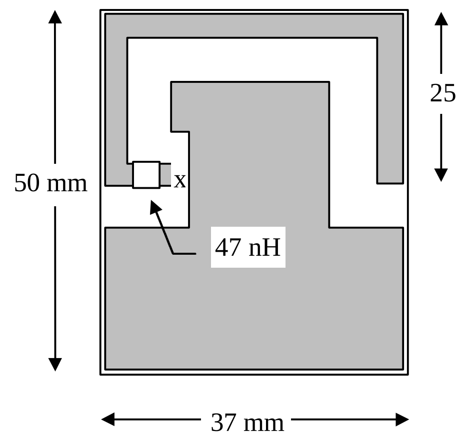
The Short PCB Stub

One big advantage for the short whip is that it can be a trace on a PCB, with a chip inductor used to tune out the capacitive reactance of the antenna. If the trace runs parallel to ground, the real part of the antenna impedance will be approximately 10 ohms. In a hand-held unit, the impedance will be raised substantially through hand effects. For a tenth wavelength strip on a board with hand effects included, the antenna has a capacitive reactance of about 150 ohms. At 433.9 MHz, this would require a 56 nH inductor to cancel the capacitive reactance of the 2.7 inch (70 mm) long line.

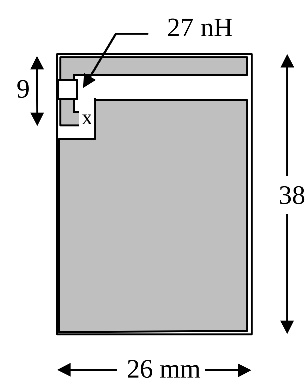
The radiation pattern will be fairly omnidirectional, with a shallow null along one axis. The polarization is roughly parallel with the edge of the board. Tuning is not extremely critical, small variations in inductor value or antenna length will not have a great effect on performance. Our sample designs, at 433.9 and 916 MHz, resulted in maximum gains of between -12.5 to -14 dBd off the side of the board. The null dipped down to about -26 dBd. This is more omnidirectional than some other designs, and hand effects will help to reduce the null depth.

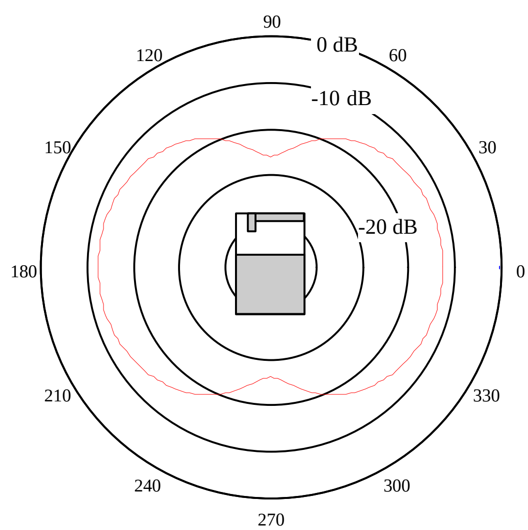
The key to this design is to keep resistive losses low, use wide traces (if a PCB trace), and good quality inductors. Adjust the inductor value for maximum output in the environment that it will be used. Gain can be improved by making the whip longer and thus reducing inductance. But, in some cases, it may be better to shorten the trace and add inductance rather than to run the antenna close to other circuit board traces.

Short Stub: 433.9 MHz



Short Stub: 916.5 MHz





Short Stub (916 MHz)

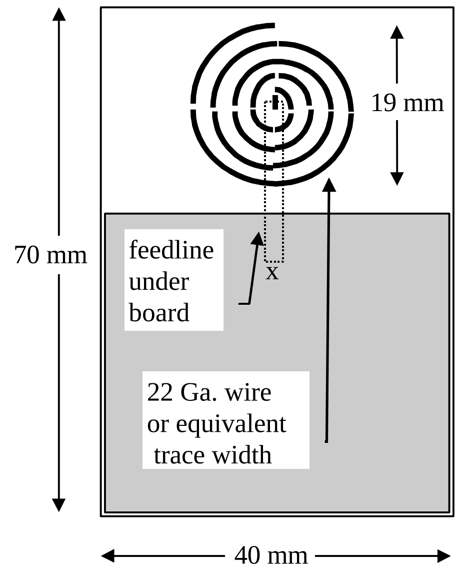
The Spiral

Another way to shorten a whip is to coil it up to form a flattened coil of wire. It can be a trace printed onto a circuit board. On a board, the length of the trace is a little shorter than a quarter wavelength. The antenna must not have a groundplane directly under it, and should occupy a clear end of the board. For example, start with a six inch long thin trace wrapped in a 0.75 inch (19 mm) square area, then trim a little of the length until it resonates at 433.9 MHz.

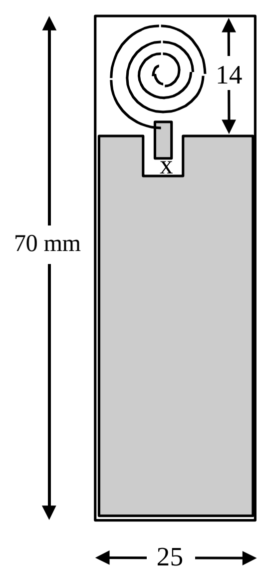
Antenna gain and impedance will vary with the size of the groundplane. Our 433.9 MHz version had a fairly small groundplane area of 17 sq. cm, while the 916 MHz version had a quarter-wave long ground. The 433.9 MHz antenna had a maximum gain of -10.5 dBd, with a small null of -24 dBd. The 916 MHz antenna had a gain of -5 dBd max. Comparable gain is also seen when looking at the board face-on.

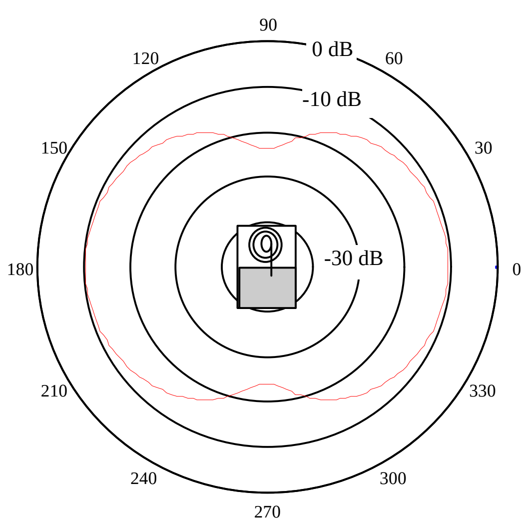
This antenna does not give circular polarization; the polarization is parallel to the long edge of the board. As with a stub, when the board is oriented vertically, it is vertically polarized and omnidirectional. This antenna is more easily detuned by a hand, which makes it less suitable for hand-held remotes.

Spiral: 433.9 MHz



Spiral: 916.5 MHz





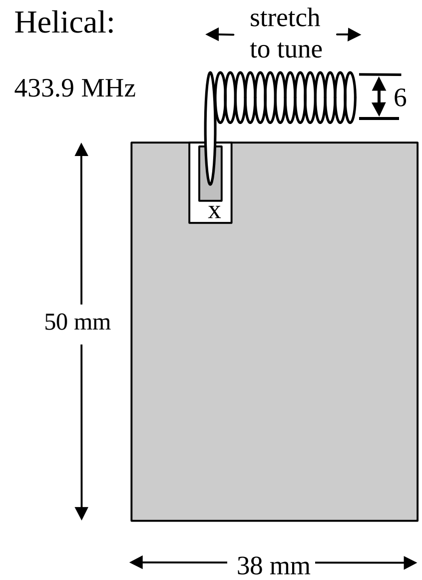
Spiral Antenna (434 MHz)

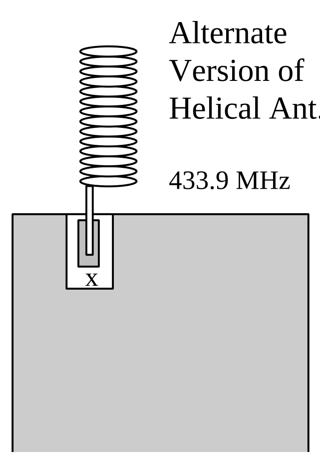
The Helical (Coil)

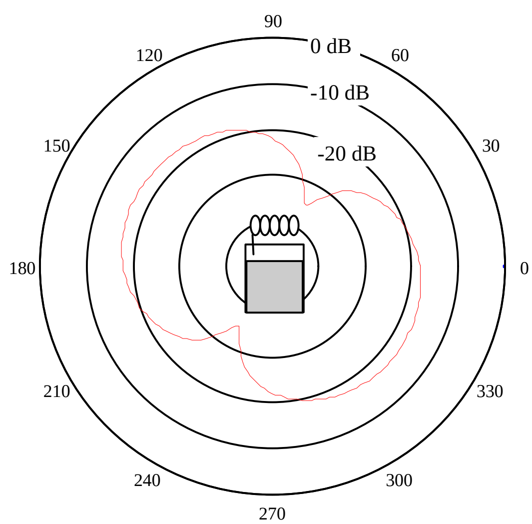
This is similar to a spiral that is not flattened. Start with a piece of wire that is 2 or 3 times longer than a whip and wind it into a coil. The number of turns on the coil will depend on wire size, coil diameter, and turn spacing. The coil will need to be cut to resonate, and can be fine tuned by spreading or compressing the length of the coil. If the coil is wound tightly enough, it may be shorter than one-tenth of a wavelength. This antenna tunes sharply, requiring care in tuning. The real part of the antenna impedance is less than 20 ohms, and depends on the size of the coil and its orientation to ground.

For 433.9 MHz, we wound 14 turns of 22 gauge wire around a 0.25 inch (6 mm) form. When tuned, it’s length was just under one inch. The proximity of this coil to ground makes a big difference in performance. When the coil runs near and parallel to ground, maximum gain is only -18 dBd. When the loose end of the coil was pulled away from ground, as shown in the alternate version drawing, gain increased to -5.5 dBd, and the null became deeper.

The big problem with this antenna is the mechanical construction and it's bulky size. It can be easily de-tuned by nearby objects, including a hand, so it may not be good for hand-held use.







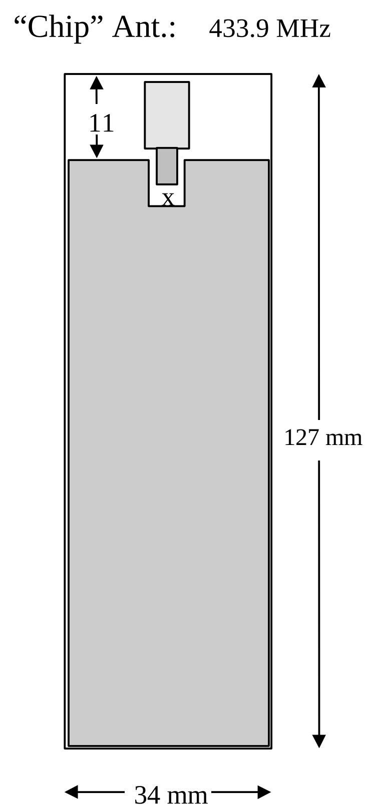
Helical Antenna (434 MHz)

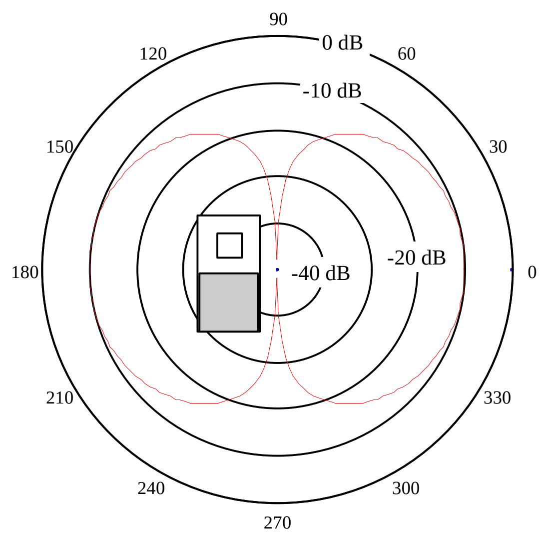
“Chip” Antenna

The latest entry into the antenna field is the tiny “chip” antenna. They are surface mount devices that are typically 8 by 5 by 2.5 mm, making them the smallest design available. They may be found for frequencies less than 300 MHz and up to 2500 MHz. These antennas are similar to whips in behavior, only much smaller. If an antenna can be reduced in size, while maintaining efficiency, bandwidth will be reduced. So these devices have a very narrow bandwidth and must be made to the exact frequency.

These devices are very groundplane dependant. As a result, they are easily detuned by hand effects, the wrong size groundplane, or even the wrong thickness and dielectric of the board. The chip antenna must be used according to the manufacturer’s recommendations.

For 433.9 MHz, we mounted a chip on a 5 inch long board and obtained a maximum gain of -10 dBd. Not bad when you consider that the spiral has equal gain, but consumes five times as much area on the board. The 916 MHz version did better with a 2.6 inch long groundplane for a maximum gain of -3.2 dBd. The polarization is parallel to the long axis of the chip, so maximum radiation is perpendicular to the long axis. There is a deep null (nearly 40 dB!) looking at each end of the chip. This would be a big problem if an omnidirectional pattern is required from a horizontal circuit board. When the board is vertical, the pattern is omnidirectional.





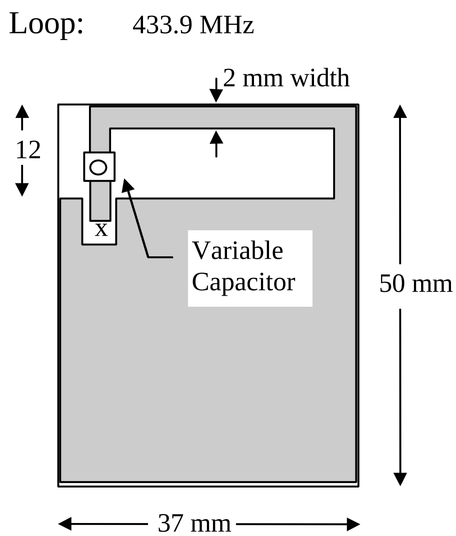
Chip Antenna (434 MHz)

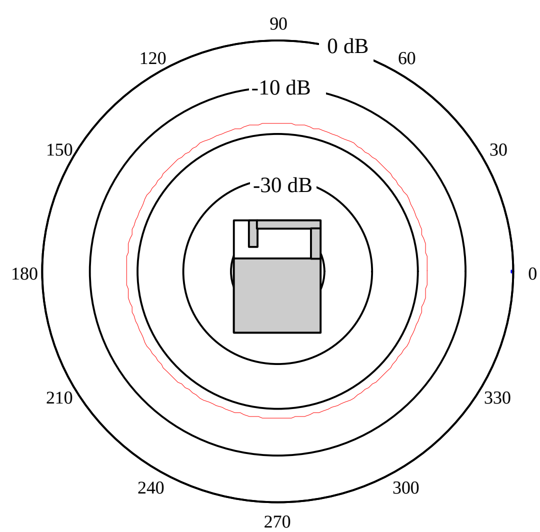
The Loop

The loop is entirely different from a whip, in that both ends of the antenna are terminated. In this case, the end that is opposite the transmitter (or receiver) is grounded. A capacitor is used to tune the antenna to a real impedance, instead of a coil. An advantage of a loop is that it is not easily detuned by hand effects, although the impedance may still vary. The loop can be made small, does not require a groundplane, and takes no more space than a short whip. For these reasons, loops are very common in hand-held devices.

There are some disadvantages. Small loop antennas have a reputation for poor gain. A small loop will have a very narrow bandwidth. This makes tuning extremely critical. Tuning is often done with a variable capacitor, which adds to the cost, both parts and labor. If the loop is large enough, it may be practical to use a non-variable capacitor. This requires careful adjustment in engineering stages, to ensure that it is properly tuned with a standard value capacitor.

Our example loop antenna covers a 12 by 35 mm area on the end of a board. It is tuned to 433.9 MHz with a variable capacitor. This antenna is very omnidirectional, but had a gain of only -18 dBd. A larger loop should have improved gain.



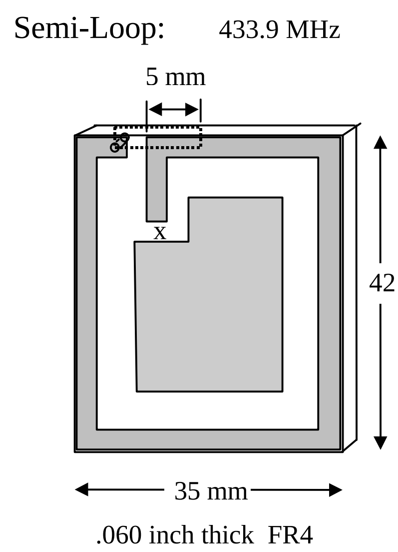


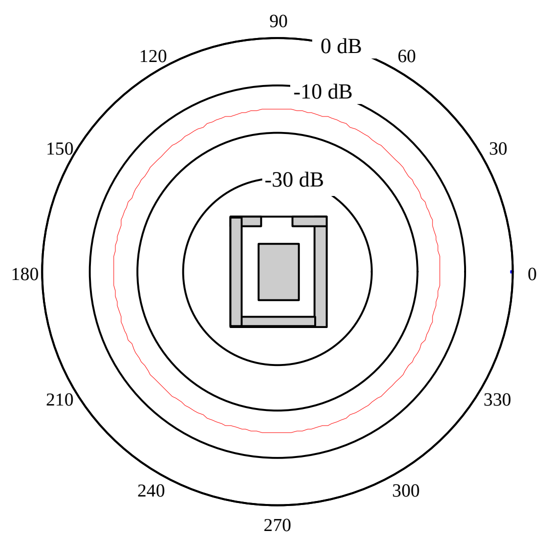
Loop Antenna (434 MHz)

Semi-Loop

This is an unusual design that looks like a loop, but requires no direct grounding. It is comparable to a loop in performance, and can be adjusted to present a non-reactive load. This antenna uses a trace that runs all the way around the edge of a small PCB. The far (open) end is capacitively coupled, through the board, back to the transmitter end of the antenna. The antenna is resonated by varying the length of the short overlapping line. Tuning is not very critical. Hand effects will improve the impedance, with little effect on tuning. Polarization is parallel to the PCB, and the pattern is omnidirectional. Our design had a gain of -15 dBd at 433.9 MHz. This design works very well for hand-held devices.

As with any other designs, this antenna should not run too close to ground. For this design, the transmitter and other circuitry, including battery, should be grouped around the center of the board, leaving the antenna in the clear. The circumference of the board needs to be well under one-quarter wavelength. We have had good results with a circumference of about 0.15 wavelength, and a line width of 1 to 1.5 mm, when used in the 400 MHz region. If the design is used on a thinner board, the 5 mm overlap will need to be shortened.





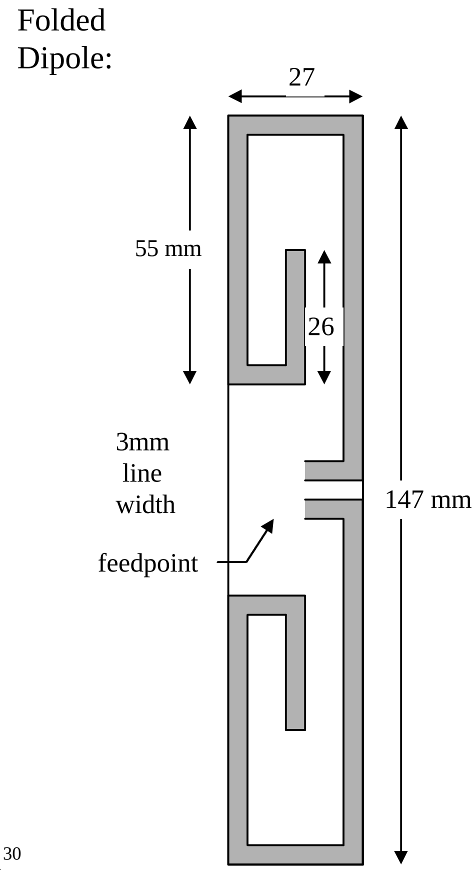
Semi-Loop Antenna
434 MHz

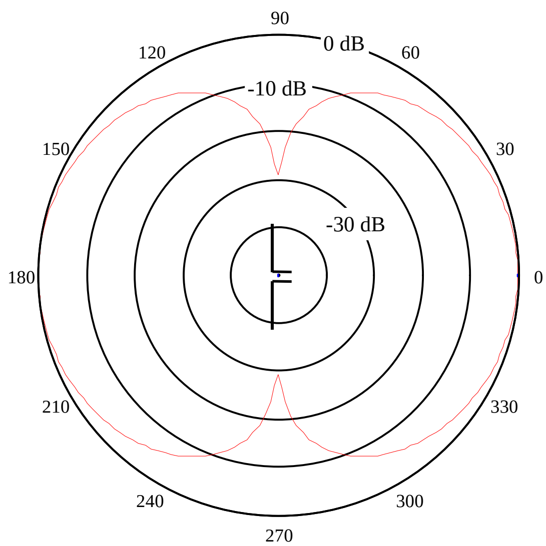
Modified Dipole Antenna

A dipole can be shortened somewhat by bending the wire or line back on itself, but not too close to itself. We built a version on a PCB, shown at right. This antenna has almost the same performance as a full size dipole, but is more compact. The thickness and dielectric constant of the board will affect the tuning, so the length may need to be adjusted.

This type of antenna is an attractive solution where space allows. However, a dipole should not be located close to a large metal area or groundplane. The groundplane will become part of the antenna, and performance will suffer.

Like the normal dipole, the radiation pattern shows deep nulls and good gain. The impedance is a little lower, but still near 50 ohms. Like many of the previous antennas, radiation from the face of the board is just as strong as from the long edge.



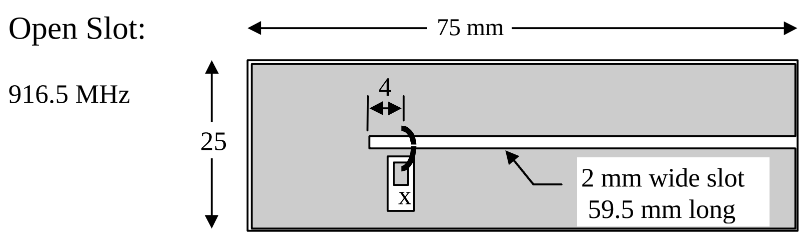


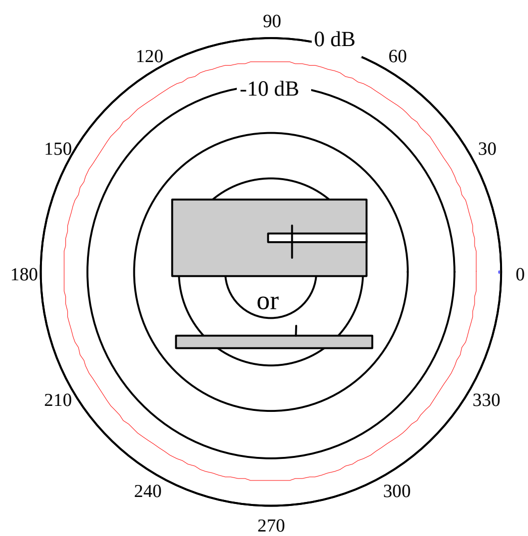
Folded Dipole Antenna (434 MHz)

The Slot

Common in radar systems and/or on aircraft, a variation of the slot antenna may have potential above 800 MHz. A quarter-wave slot is cut into a metal sheet or unetched PCB, and if enough area is available, will provide omnidirectional coverage. Our sample antenna at 916 MHz required a 75 mm long PCB. The length of the slot was 59.5 mm for 0.060 inch (1.5 mm) thick FR4. A different thickness or dielectric will require changing the length of the slot. One end of the slot must be left open. The slot was fed near the closed end, in this case 4 mm from the end. The feedpoint impedance can be adjusted by moving the feed toward or away from the closed end. Tuning is somewhat critical.

When the board is horizontal, the pattern is omnidirectional around the edge of the board, thus horizontally polarized. We also see omnidirectional coverage when the board is vertical (with the slot horizontal). In this case, polarization is vertical! It may not make sense, but a horizontal slot is equivalent to a vertical whip in this case. Gain is -4.5 to -6 dBd. The feed can be a trace on the backside of the board, with a via used to make connection with the top of the board near the slot.





Half Open Slot Antenna
(916.5 MHz)

The Patch

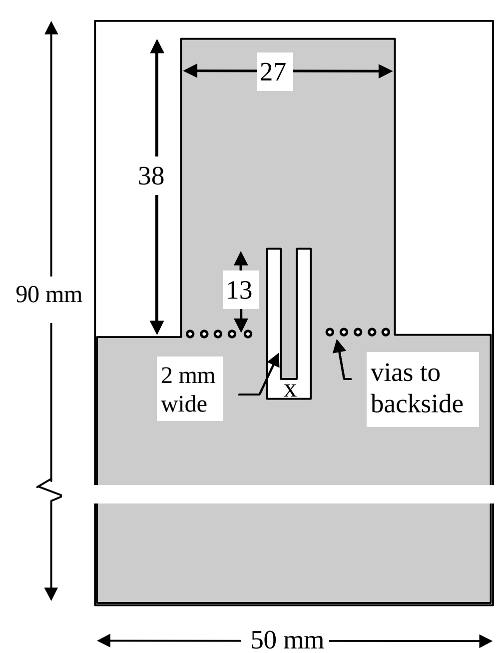
The Patch antenna is a very low profile design, which consists of a round or rectangular patch of metal very close to a groundplane. The patch is usually printed on a circuit board and can be made as part of the enclosure. Antenna coverage is in any direction above the groundplane, or a hemispherical area. The patch antenna does require a substantial amount of area on a PCB, which makes it more practical above 800 MHz. It has a narrow bandwidth so care must be taken to tune the size of the patch carefully. It is sensitive to the thickness and dielectric constant of the PCB and small variations will mistune the patch completely. It is also sensitive to coatings, but not extremely sensitive to hand effects.

A practical example for 916 MHz can fit into an area only 30 by 40 mm. The patch size is 27 mm wide by 38 mm long for a board thickness of 0.060 inch. A thinner board or higher dielectric can require cutting the antenna a little shorter. About one-tenth of an inch of board space should be left around any ungrounded edge of the patch. One edge of the patch should be grounded with multiple PCB vias. The antenna is fed with a line crossing through the grounded edge to the 50 ohm point on the patch, or by a transmission line coming up through the bottom of the PCB. The 50 ohm point is about 13 mm away from ground on our example patch. The 50 ohm point for any design can be found by moving the vias toward or away from the grounded edge. The farther the feed is away from the ground vias, the higher the impedance will be.

This type of patch is not a full-size, half-wavelength patch, so performance is not as good as a larger size patch. A full-size patch has no grounded edge, so vias are not required. Our example rectangular patch has a gain of -8 dBd. Placing the board against a larger sheet of metal will improve the gain by another 4 dB. If the antenna is made wider than one inch, up to about 3 inches wide, a few more dB can be gained. Polarization is perpendicular to the grounded edge. Gain is good in almost any direction where the patch can be seen, but drops rapidly when looking at the edge of the board.

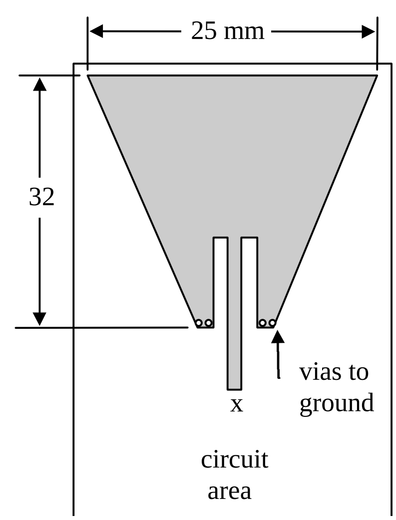
The trapezoidal version allows for less length so that it can fit into smaller spaces. Patterns and behavior are the same, but the gain is a little lower. We measured about -12 dBd maximum, on a 40 by 90 mm board.

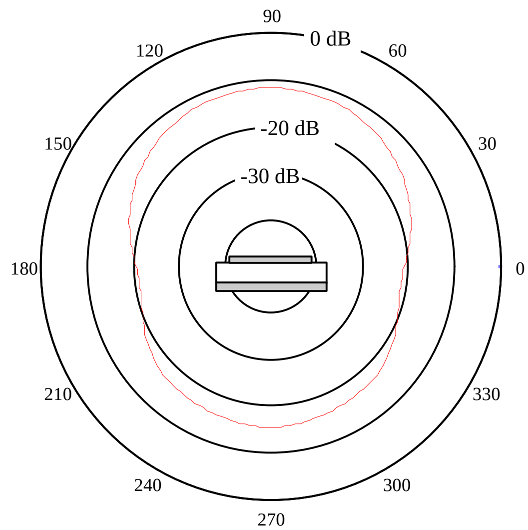
Rectangle Patch: 916.5 MHz



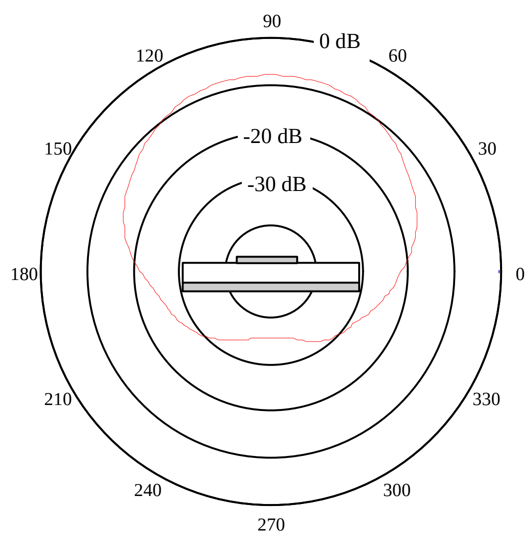
Trapazoidal Patch:

916.5 MHz





Trapazoidal Patch over a
Small Ground Plane
(916.5 MHz)



Trapazoidal Patch over a
Large Ground Plane
(916.5 MHz)

Enclosures

An antenna should not be located inside a conductive, or metal enclosure. Care should be taken to keep the antenna away from metal surfaces. If a conductive area is large in terms of wavelength (one half wave or more), it can act as a reflector and cause the antenna to not radiate in some directions. If a metal box is used for an enclosure, an external antenna is required.

Testing and Tuning

Antennas may seem to be a mystical art. Unlike many electronic devices, any change in nearby materials or dimensions can affect antenna performance. Trying to build a published design does not guarantee results. Testing an antenna design is necessary, tuning is usually required, and there are pitfalls along the way.

A network analyzer is normally used to test the impedance or VSWR of the antenna. Some antennas that have an impedance near 50 ohms can be tuned by looking at return loss or a VSWR display. Low impedance antennas may require the use of a Smith Chart display to get good results. In this case, the antenna should be tuned to a point near the pure resistance line.

There are other options, such as a spectrum analyzer with a tracking generator, that can be used with a directional coupler. The coupler will feed power to the antenna while feeding the reflected power from the antenna back to the analyzer. The coupler must have an isolation between the Generator and RF Input Port of 20 dB or more. Calibration is done by noting the power readings with a 50 ohm load connected and then unconnected. Using this technique, “return loss” can be measured. If the antenna is near 50 ohms, the return loss back to the RF input port will be high, due to the antenna absorbing most of the power. A good antenna will show as a dip on the screen at the correct frequency. A dip of only 3 or 4 dB (about a 5:1 VSWR) is normal for a low impedance antenna measured on a 50 ohm analyzer. A dip of 9 dB (about 2:1) or more indicates a well-matched antenna in a 50 ohm system. If the dip is not centered at the right frequency, the antenna length or tuning needs to be adjusted.

Antenna measurements of any kind are tricky since the antenna is affected by nearby objects, including the size and shape of the circuit board, and even by the cable connections to the network analyzer. Pass your hand close to the antenna and the dip should move around a little. If it does not, the antenna may not be connected properly. Antennas that are ground plane sensitive may see all additional wires as an extension of that ground. Try wrapping your hand around the cable that goes to the analyzer. If the measurement changes much, you may need to try a different tactic. One possibility to minimize RF currents on the cable is to put a few good high frequency ferrite toroids or some absorptive material over the cable.

The best way to fine tune a remote transmitter antenna is by using the transmitter itself. Put an antenna on a spectrum analyzer and try to keep other large metal objects out of the way. Find a place to locate the transmitter that is away from metal and a few feet away from the analyzer. Always locate the transmitter in the exact same spot when testing. If you have a desk that is wood, mark it’s position with a pencil or tape. If hand held, hold it in your hand just above the marking on the desk. Be sure to position your hand, and the rest of your body, the same way during each test. Take a reading of the power level, and tune the antenna to achieve maximum radiated power. The same thing can be done for a receiver. Transmit a signal to it, and adjust the antenna to receive the lowest signal level from the generator.

Common problems with antennas usually involve insufficient free space around the antenna. The antenna cannot run close to ground or any other trace without effecting the antenna performance. This includes traces on the other side of the board, batteries, or any other metal object.

Receiver performance can be degraded by digital circuits. Digital switching is very fast and creates high frequency noise that can cause interference. Keep receiving antennas away from digital circuit traces. Try to keep digital traces short, and run them over a groundplane to help confine the electromagnetic field that is generated by the digital pulses. If an external antenna is used, then use a coaxial cable.

A transmission line for G-10 material that is .06 inch thick requires a trace width of a tenth of an inch , half of that for a .03 inch thick board. This results in a 50 ohm transmission line that will carry RF with minimum loss and interference.

High static voltages may damage sensitive semiconductors or SAWs. We recommend placing an inductor between the antenna and ground to short out any static voltages. For the 400 MHz region, a value near 200 nH is a good choice. At 916 MHz, a more appropriate value may be 100 nH.

Acknowledgments

The author would like to thank John Anthes, Harry Boling, and Jeff Koch for their assistance in the preparation of this paper.

40/20 trap dipole

Here's an easy to make trap dipole for 40 and 20 meters. I made this for portable operations, mostly for "to the field" type QRP contests. Being able to switch bands between 20 and 40 quickly and without re-adjusting an antenna tuner is a nice feature. The only problem is it's a little heavy with the feed line and all, and putting it up in the raw New England woods can be daunting. Generally, I deploy it as an inverted "V".

Wire lengths:

I use #22 Teflon insulated wire. It slips around pine tree branches easialy.

20M section: 17.0 feet. 40M section: 14 feet, 8 inches.

You should add a few inches to these lengths so that the antenna can be trimmed. Easier to cut wire than to add it! You'll need about 6" extra on the 40M section to make a half hitch to attach a support string to. If your using insulated wire anyway, there is no need for an insulator and its extra weight and bulk.

.. Half hitch at end of 40M wire for attaching support string to.

Trap:

The trap is wound on a T50-2 core, with 24 turns. A 47 pfd mica cap is placed across the coil to tune the trap to about 14 MHz. The trap is then mounted to a piece of PCB board, with the copper removed, which acts as a strain relief when attaching the wires to it. Drill 2 holes close to each other on either end of the board, then pass the wire down into one, and up through the other and solder to the trap. I covered my trap with some black liquid rubber to protect it from the elements and hold it down to the board.

..Trap on pcb board.

Center support:

There are any number of ways to attach the feed line to the antenna wires. Here's one made from a 1" OD PVC pipe cap. I didn't make this, it was supplied with the N2CX "Gusher" antenna. It makes a nice universal center connector, as one can easially change the wires for different bands or configurations. It is easially duplicated.

The coax (RG-174 in this case) passes through a hole drilled into the bottom of the PVC cap. Its a good idea to put a knot in the coax, so it doesn't pull out. Once the coax has been soldered to spad lugs and connected to the screws on the side of the PVC cap, the cap is filled with 5 minute epoxy. Before the epoxy fully sets up, insert a small screw eye. This gives you an anchor point for a support string, so that the antenna can be pulled up into a tree, without putting stress on the wires.

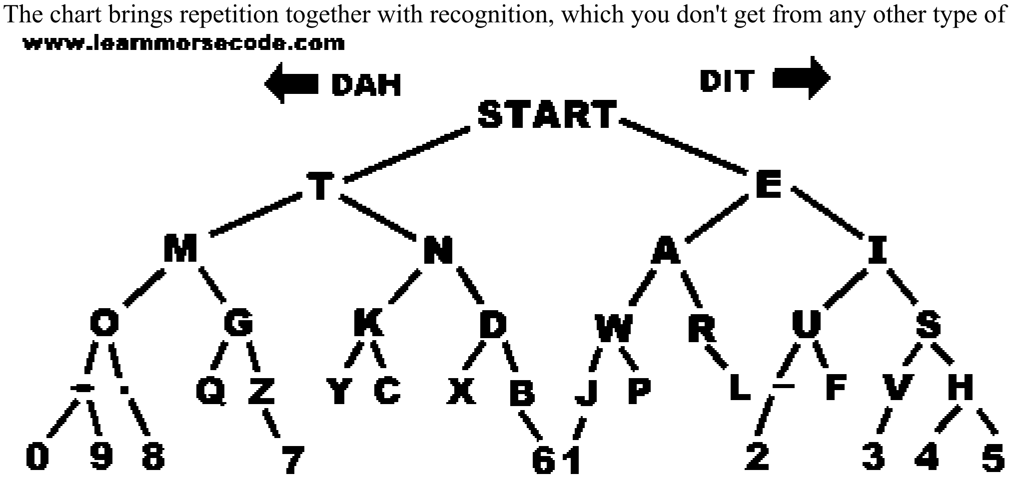
Trimming the antenna:

Before you go and try to use this antenna in the field, you should set it up and check out it out. An antenna analyzer or "Tenna Dipper" is a good QRM free way of testing for resonance and is a lot easier than running back and forth to the rig and SWR bridge! Test and trim the 20 meter section first, then do the 40 meter ends. Once you get a 1:1 match where you want it on both bands, your ready to go out into the field with it!

HOME

LEARN MORSE CODE in one minute !

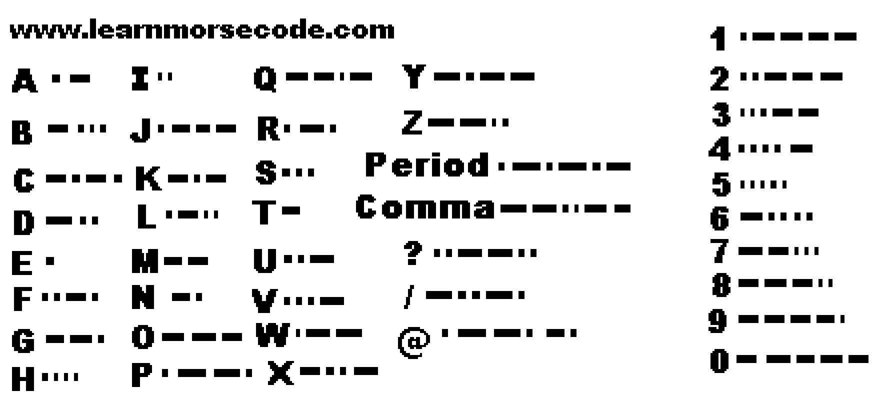
This is a code listening tool. Print it on your printer.
Place your pencil where it says START and listen to morse code.
Move down and to the right every time you hear a DIT (a dot).
Move down and to the left every time you hear a DAH (a dash).
Here's an example: You hear DAH DIT DIT which is a dash then dot then dot.
You start at START and hear a DAH then move down and left to the T and then you hear a DIT so you move down and RIGHT to the N and then you hear another DIT so you move DOWN and RIGHT again and land on the D
You then write down the letter D on your code copy paper and jump back to START waiting for your next letter.
The key to learning the code is hearing it and comprehending it while you hear it.
The only way to get there is to practice 10 minutes a day.
Listen to code tapes or computer practice code while tracing out this chart and you will find yourself writing down the letters in no time at all without the aid of the chart.
The chart brings repetition together with recognition, which you don't get from any other type of code practice aid.



HEAR slow morse code This code speed is slow enough to follow the chart above.

LEARN the DITs and DAHs with these MP3 files:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z 1 2 3 4 5 6 7 8 9 0



And the character to emphasize that there she was, she was walking down the street, is :
do-wah-diddy-diddy-dum-diddy-do

Goto DOWNLOADS page for hours of MP3 code practice

Goto LINKS page

Goto CARC Carbon County club

Goto BRAILLE page

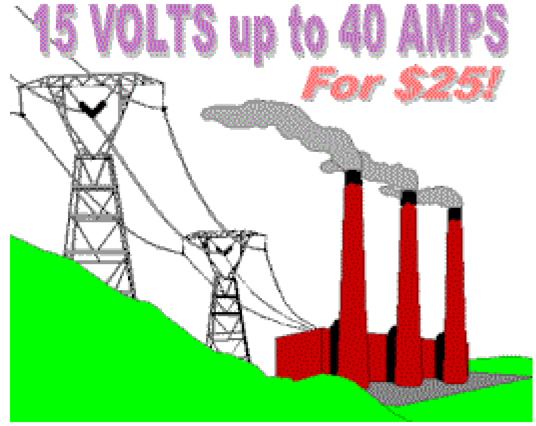
email KB3BYT

HOW TO LEARN MORSE CODE AND ENJOY IT

FOX HUNTING ANTENNA PLANS

Who really invented Morse code?

By August Hoecker, W8MIA
w8mia@antennex.com



OVERVIEW

If you are an amateur radio operator, Short Wave Listener (SWL) or involved in any number of other areas of communications, sooner or later you will have a need for a high current, well-regulated 12 to 15 volt DC power supply. It may be that you have removed your all band, 100-watt "Super Band Banger" rig from the car for the winter and need a power source to handle that transmit load. Or perhaps you have your station all setup with emergency battery backup and require a much shorter recharge cycle to get your batteries ready for the next black out. Whatever your reason, if you have a use for such a supply ranging in output current from 25 to over 40 amps this idea may be the one for you. If you have priced such a supply, you will find the cost is in the range $200 to $300 (US$). Discussed here will be a way to cut that cost by a factor of 10!

HOW DO WE GET THERE?

Developing a power supply providing 15 VDC or less, at the currents discussed is more of a search and find mission than it is a high tech one. If you are one of the newer members of our amateur radio family or new to needing a high current power or charging system, this relatively straight forward project should not stretch your technical skills and more importantly it will not stretch your budget either! The task at hand is to look through your "junk box" or visit your local "Radio Goodies" store or perhaps better yet, a computer store that sells old equipment and used parts. You will be looking for used but working Personal Computer power supplies. The ones I found were purchased at a "Good Will" store, still mounted in three scrapped out "AT Chassis" for $5 (US$) each—see Photo-1. In this case I not only obtained the three wanted supplies, that were all alike but I also acquired the cases, power switches, AC power cords, etc. The cost was low enough to allow the purchase of two additional units to keep as spares or for other service. You can also use the old PC cabinet for mounting multiple supplies if you desire.

ABOUT COMPUTER POWER SUPPLIES

It may be worth a few minutes of your time, for those of you who may not have had any exposure to a typical PC power supply, to grasp a general understanding of their inner workings without us going into any great detail. The power supplies I am discussing are enclosed in a metal case about 5 x 6 x 7 inches (13 x 15 x 18 cm) containing their own cooling fan, circuit breaker, power switch (case mounted or on short wire leads to the case) and a standard computer 3 pin IEC power connector. The power ratings of these supplies vary greatly from as low as 135 watts to over 300 watts. This wattage rating expresses the total power output of the supply. You will be searching for supplies no smaller than 200 watts with bigger being better with only one caveat discussed a bit later.

The PC power supplies described will normally provide four output voltages which are + 12 VDC, -12 VDC, +5 VDC and -5 VDC. The two minus voltages are usually rated at about 1 amp or less each and are of no practical value for our use here and you may just disregard them. The plus 12 VDC will have an output current rating of anywhere from 7 to 14 amps DC. The 5 VDC output rating will range between 20 and 40 amps depending on the output wattage rating of the supply.

The units used for my supply were manufactured in Taiwan by "KPI ", with a power output rating of 250 watts which turns out to be a very conservative rating for this particular supply. The +12 VDC is rated at 10 amps with the + 5 VDC rating at 25 amps! These two power outputs loaded to their full rating will add up to an output power availability of 245 watts, very near its posted rating. As shown, we have +5 VDC

and +12 VDC and several options and a few restrictions for their use in assembling this new supply to suit our needs.

One important point with reference to these computer power supplies is that they are "switching" power supplies not the more conventional "linear" type supplies so many of us may be more familiar with. There are several distinct advantages of switching supplies over the older linear types. Mainly they are more efficient and run cooler. However, there are also a few things to be cautious about or have knowledge of when using these supplies. The first item comes under the **CAUTION** flag. Switching power supplies take the AC line voltage (100 to 240 VAC, sometimes requiring a jumper to be removed for the higher line voltages) rectify it and charge high value capacitors to ***a high voltage in the range of 250 to 400 VDC***. These high primary voltages do present a dangerous lethal shock hazard and caution must be used if you decide to remove the protective cover over the supply and poke around inside. If you do decide to do so ***always discharge*** the large high voltage capacitors within. **Always!!**

One disadvantage of switching type supplies, in particular the older units, is their requirement for a minimum load on their output terminals. This will be in the range of 2 to 4 amps on the +5 volt output and from 0 to 2 amps on the 12 volt output. Many supplies require this minimum load on the +5 volts only. This may present a problem depending on the type of service you intend to place your supply into. One quick, simple fix is to place a 1 or 2 ohm, 25-watt load resistor across the +5 volt output. Although you are wasting from 12.5 to 25 watts of power, this will settle the supply down and allow it to provide a stable, well regulated output on both the +5 and +12 volt outputs. This is also a good technique to use when first testing your new supplies. An additional load resistor may be necessary on the +12 volt output, if so required, depending on the supply in question. This is the caveat mentioned earlier, but will usually not present a big problem. The two GE receivers in my rack draw enough power alone, on the 12-volt bus, to provide this load. I felt however it was necessary that you be made aware of this factor when dealing with switchers. Without this load present at "**power on**" the output voltages will not come up.

PUTTING THE SUPPLY TO WORK

At this point you have three options for the use of the supply outputs. First, if your load is at or less than the 12 volt maximum rating you may connect your equipment to the black and yellow leads supplying the voltage to the four pin Molex-type connectors coming from the supply. For higher power equipment, parallel several or all of the black leads together and do the same with the yellow leads to minimize your voltage drops. Connect your load to these new junctions. All wires of the same color are the same voltage. All black wires are common ground or reference point for all voltages. More on this "ground" connection a bit later. There is a long cable coming from the supply containing about twelve wires. This cable formally connected to the motherboard in the PC. This may be used as a source of your power. The color codes remain the same.

Your second means of utilizing this low cost power is to connect the +5 VDC outputs of three separate supplies together in series. This will provide you with +15 VDC at 25 amps on up to the maximum rating of the supplies you have acquired. If this +15 volts is beyond the working voltage range of your equipment, once again you have two options. One simple solution is to place one or two 50 amp stud diodes, with a heat sink, in series with the +15 VDC output. This will reduce the output voltage to 14.3 or 13.6 VDC respectively. It will also provide isolation between the supplies and any standby batteries you may have in your system. 13.6 to 13.8 VDC is also an excellent float charge voltage to keep your sealed lead acid batteries well charged without overcharging. An alternate to the added diode method is to remove the covers on the three supplies and look for the +5 V voltage adjustment. Most all computer supplies provide at least a +5 VDC adjustment. Many provide a +12 VDC adjustment as well. Once again "**Use Caution**" when you have the supply uncovered. In particular while AC primary power is applied. Locate the +5 VDC adjustment pot and set each supply output to from 4 to 4.5 volts which will provide a combined output between 12 and 13.5 VDC or as required for your needs.

Your last option is to use both the first and second choices above. Except for the common ground connections (black leads) each of the supply voltages are independent and isolated from each other. As

an example, I power my two GE Master transmitters using the high current series connected 5 volt supplies. I power each receiver independently with the 12 volt outputs of two of the supplies and use the third 12 volt output for other monitor and scanning receivers with lots of 12 volt power to spare.

A few closing thoughts: Although there may be a few variations by certain manufacturers, the standard color coding of these PC power supplies is as follows: (See L-1)

Table L-1

COLOR	VOLTAGE	COMMENTS
RED	**+5 VDC**	**All red wires common to each other**
YELLOW	**+12 VDC**	**All yellow wires common to each other**
WHITE	**-5 VDC**	**Not Used**
BLUE	**-12 VDC**	**Not Used**
BLACK	**Common Grd.**	**All black wired common to each other**
ORANGE	**+5v Signal Wire***	**Power Good Lead, connect to +5 VDC**

Note: Most PC Power Supplies have an ORANGE wire that provides the **"Power Good"** signal back to the supply. Tie this wire to the +5 VDC leads. Not all supplies have this feature, however, the supply will provide no output voltages without seeing a positive going 5 v signal on this line.

Switching power supplies have several unique properties. Among these is their ability to "Power Share" between supplies. This means that although the +5 volts may be rated at 25 amps, it will be capable of supplying a larger output current that if the +12 volt supply is lightly loaded. You cannot push things too far due to the limits of the power components within the supply. There is a fair amount of leeway in most supplies however.

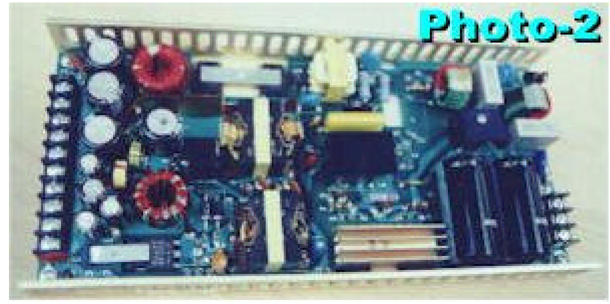
If a switching supply is overloaded or short-circuited, it will shut down. Its out voltage will drop to zero. Do not attempt to improve the filtering of the output power by adding an additional, large filter capacitor across the output. When the supply first begins to come up it will see that large cap as a short circuit and shut the supply down. Adding an additional capacitor will not only create a problem you will find it is not necessary!

It is suggested, if you are using more than one supply, (the three in series for example) connect all primary main power input circuits together so they are all powered on at the same time. Also, although the switching power supplies suggested here are quite efficient while operating they will draw a large surge for the first several cycles of primary power after you turn on the AC power. Be sure your AC main supplying the primary power is not overloaded with other heavy current equipment. After they are switched on however, the three supplies in series will draw about 1100 watts maximum under full load.

One last caution. Many power supplies connect all of the "black" wires, DC common, to earth (3^{rd} wire ground). If this is so with the supplies you have on hand, you must open up the supply and cut the trace or traces that tie this DC common point to ground so the outputs are all floating. This will ONLY have to be done to the second and third supplies. The first supply will have its Black DC Common lead connected to ground in most installations and need not be touched.

If you have considered simply connecting the three 12 VDC outputs together in parallel you must diode isolate the positive lead in each supply before connecting them together. Although this will work fine and provide higher output currents, the output voltage will drop to 11.3 VDC. This can be reduced somewhat through the use of barrier diodes, but the output will now be approximately 11.6 volts. If the +12 VDC is adjustable in your supplies this will not present a problem simply readjust the pot to compensate for the

series diode voltage drop.



As an alternative to using standard PC power supplies there are many open frame, high current, +5 and +12 VDC supplies available (see Photo-2) at very reasonable prices on the used and surplus market. In fact there are several listed now in the ***antenneX*** **Classified Clearing House** (CCH) listing under power supplies. Remember please "**USE CAUTION**" when you have your fingers inside these switching supplies. Although their output voltages are very tame there is a "***Tiger in The Cage with Lethal Teeth***"! **-30-**

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Last modified: April 01, 2001

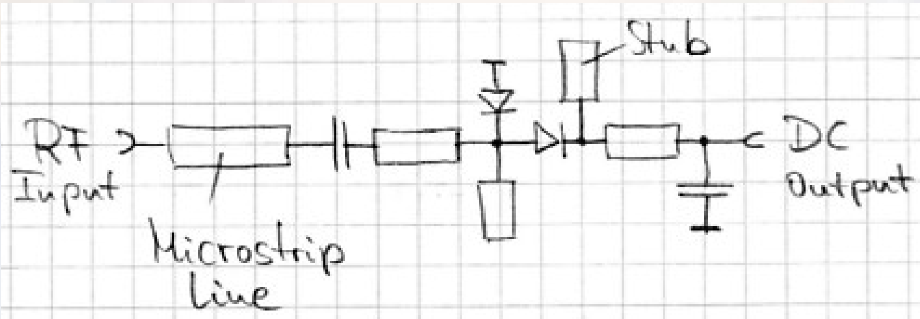
Prof. Dr.-Ing. K. Solbach
Prof. Dr.-Ing. A. Beyer

Diplomarbeit / Masterarbeit

Task: Rectifier Circuit for Microwave Power RF-to-DC Conversion

Description of Project:

For an ongoing concept demonstrator project, a microwave power signal (about 1 Watt at 2.5 GHz) has to be converted into direct current (DC) to provide a power supply for a remote sensor which is fed by microwave radiation. The present demonstrator uses a rectifier circuit based on a design taken from a recent publication, which employs Schottky diodes designed for lower power switching / mixer applications at microwave frequencies. The resulting DC output power of the rectifier is low (low conversion efficiency) and strongly dependent on the load resistance (or load current), while the achieved DC open-circuit voltage is limited to about 4 Volts which indicates a cut-off problem of the diodes (reverse break-down voltage).



Thesis task:

The task of the thesis is to optimize the RF-to-Dc conversion circuit using nonlinear simulation (applying our network simulation tool ADS) and experiment. In particular the task entails the following steps:

- Check the literature for applicable RF-DC conversion circuit designs, in particular the literature on RFID transponders
- Select applicable Schottky diodes and extract nonlinear models from the manufacturers' libraries or from ADS.
- Set up a network in ADS, based on the present circuit design and analyze the function of the circuit; check the effects of the diode parameters (knee voltage, reverse capacitance, forward resistance and reverse break-down voltage).
- Optimize the design by variations in the matching and filter circuit portions.
- Investigate the performance of the design as a function of input power and DC load current.
- Investigate the performance of a combination circuit with two rectifier circuits each fed by half the RF power and parallel combination at the DC output in order to achieve double the current.
- Build a circuit in microstrip technology and test its performance; try to improve input match using microstrip stubs at the input line.

Germanium Diode AM Radio

LAB
3

3.1 Introduction

In this laboratory exercise you will build a germanium diode based AM (Medium Wave) radio. Earliest radios used simple diode detector circuits. The diodes were made out of Galena crystals (also called cat's whisker) and these radios were really simple. Despite all of the advances in modern electronics, there are thousands of crystal sets in daily use throughout the world. A crystal receiver is powered solely by the radio waves that it pulls from the air. Figure 3.1 shows the picture of an early Ge diode radio.

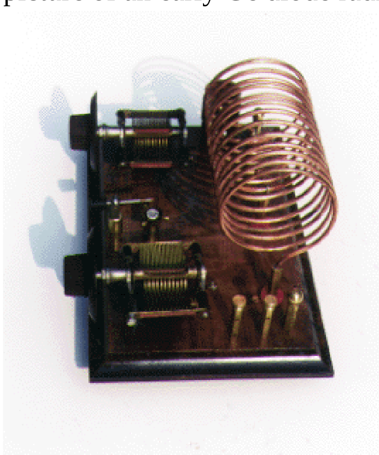


Figure 3.1—An antique diode radio. This radio is a MW and SW radio that works without any power supply.

Amplitude Modulation

The point to modulation is to take a message bearing signal and superimpose it upon a carrier signal for transmission. For ease of transmission carrier signals are generally high frequency for severable reasons:

1.For easy (low loss, low dispersion) propagation as electromagnetic waves

2.So that they may be simultaneously transmitted without interference from other signals

3.So as to enable the construction of small antennas (a fraction, usually a quarter of the wavelength)

4.So as to be able to multiplex; that is, to combine multiple signals for transmission at the same time.

For example AM radio is 550-1600 KHz, FM radio is 88 MHz-108 MHz, TV is 52-88 MHz (channels 1-6), 174-216 MHz (channels 7-12) and 470-900 MHz (UHF).

In Amplitude Modulation (AM), the amplitude of the high frequency signal is varied by a low frequency signal that needs to be transmitted. Figure 3.2 shows a

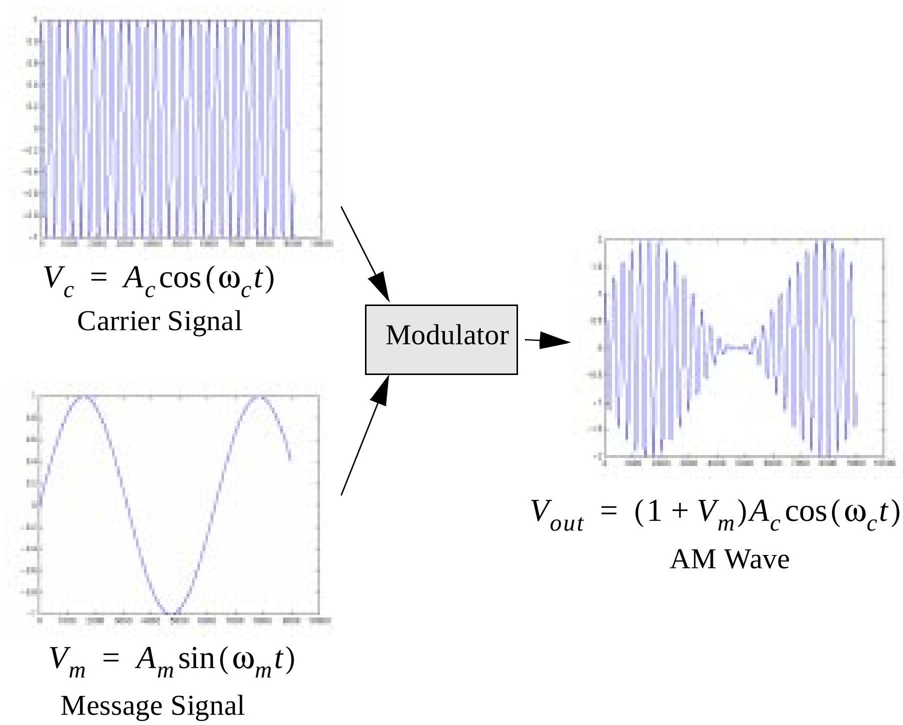


Figure 3.2—Amplitude modulated signal consist of a message signal V_m controlling the amplitude of the carrier signal V_c

message signal and a high frequency carrier signal multiplied to obtain the AM modulated signal. The carrier signal is the content transmitted by the radio station and the carrier is the frequency which the electromagnetic waves are transmitted.

AM Detection

Modern radios use complicated detection schemes to demodulate the transmitted electromagnetic waves to provide the kind of reception we have began to expect from our radios. However, the simplest way to demodulate the transmitted AM waveform is use an antenna, a tuned LC coil, a germanium diode and a earphone. In this lab we shall attempt to build the radio the earliest pioneers built using these simple components.

3.2 Diode detector

Figure 3.3 shows the circuit for the MW diode detector based radio receiver.

Antenna

The antenna's job is to capture electromagnetic waves from all sources and directions and funnel those charges into the antenna coil. The amplitude of received signals is directly proportional to the dimensions of the antenna. Antenna design

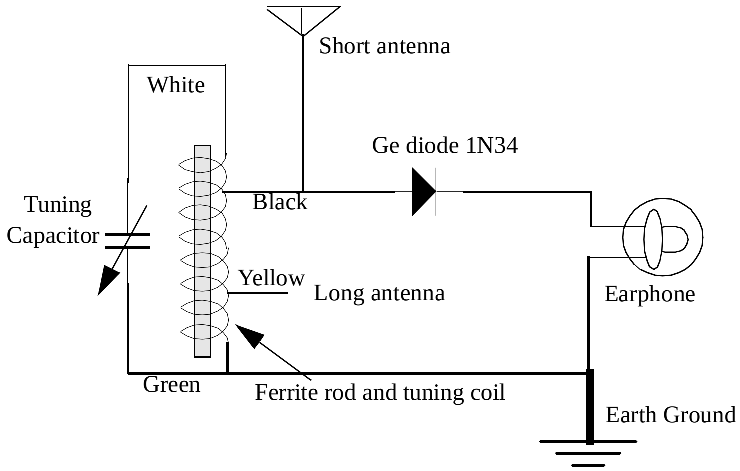


Figure 3.3—Schematic of the MW AM diode radio detector to be designed.

is not trivial and requires outdoor mounting. In this lab, since we are inside and without an amplifier, we expect to have poor sensitivity.

Earth ground

The earth ground connection effectively extends the antenna into the earth, which contains electrical signals. Keep the ground wire as short and straight as possible. There may be some sensitivity loss if the excess ground wire is coiled into a loop. Use the power supply ground (Earth) for this connection.

Tuning coil

The tuning coil is the inductor which, in series with the tuning capacitor, determines the resonant frequency of the receiver:

$$f_{res} = \frac{1}{2\pi\sqrt{LC}} \qquad \text{(Eq. 3.1)}$$

Where L is the inductance of the coil, and C is the tuning capacitor. The amount of coupling (Q factor) is directly proportional to the distance between the windings. If you slide the windings far apart, there is little coupling and a narrow resonance peak (e.g., 100 KHz). If you move the windings closer, there is more coupling and a broader resonance peak (e.g., 200KHz). A broader resonance peak will mean less selective tuning; that is, several stations will be heard simultaneously at one tuner setting.

A tuning coil is provided to you. Connect it up as shown in Figure.

Tuning capacitor

The tuning capacitor is the variable component in the “tank” circuit which comprises the coil and the capacitor. By varying the capacitance, you can change the resonant frequency of the receiver within the limits of the coil inductance and the

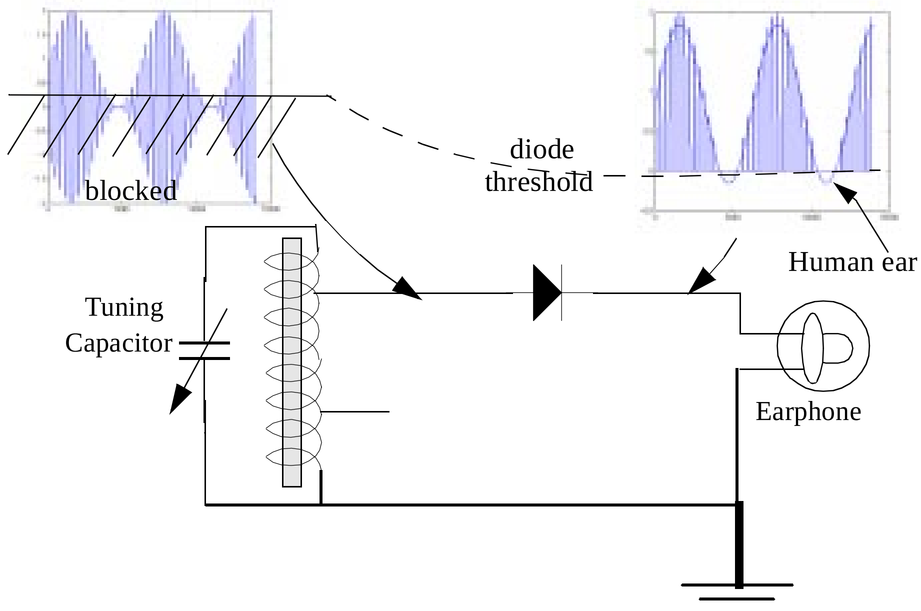


Figure 3.4—The waveforms at various points with an input AM as described in Figure 3.2

total capacitance available in the variable capacitor. A 50-500pF variable capacitor is provided. This enables us to tune from about 550 to 1600KHz.

Detector (diode)

In this radio, a diode serves as the detector, separating the fluctuating direct current (containing the voices and music of the broadcast) from the amplitude-modulated, radio-frequency, alternating-current carrier wave that was transmitted from the radio station antenna. The direct current generated by the detector will drive the output device.

Earphones

The output device changes the electrical energy in the detector circuit into mechanical energy that moves air against our ears to create sound.

3.3 Working of the diode detector.

The electromagnetic waves from the transmitted from the radio station are picked up by the antenna. The impedance of the LC circuit is very high at the resonant frequency and very low at all other frequencies. This means that only the frequency at which the LC circuit is tuned to develops a voltage across it.

The Germanium diode that has a low cut-in voltage allows current only in one direction and only the one half the cycle is transferred to the earphone. The earphone acts as a low pass filter as it is designed for the human ear (20Hz-20KHz). The waveforms at various points of the circuit for a modulated signal in Figure 3.2 is shown in Figure 3.4. Note that it is difficult to actually see audio waveforms on an oscilloscope so a test signal with a single message frequency must be used.

3.4 The Experiment

The inductor and the variable capacitor to need to be soldered on to a separate printed circuit (PC) board so that it is easy to connect them to the bread board. The wires from the inductor are multi-strand and are difficult to plug into the proto-board. Soldering also reduces the parasitic capacitance that could cause tuning frequency drift (Why?).

Hook up the circuit as shown in Figure 3.3 with the LC circuit mounted on the printed circuit board. Making sure that the coils are connected with the proper color coded wires and the diode polarities are correct. Note the diode polarities are not really important for the operation of this circuit (Why?).

Establish the ground connection by connecting to the earth of the voltage supply.

Make an antenna anyway you like from the wire provided (what criteria?). A good choice is to make the wire length about one-fourth of the *wavelength* of electro-magnetic wave you are trying to receive. *Perform some prelab research and calculate the wavelengths that you need. Show you work in your lab book and in your report.*

Listen carefully to the earphone and play with the tuning capacitor to find a radio station. Warning: It might be difficult to tune into any signal radio station. You may need to listen really hard.

Suggestions to improve performance

Hookup up an Operational amplifier base voltage amplifier to this circuit so that the output is large enough to be heard using the headphone. Hint: Make a gain of at least 10 in the first stage. The preamplifier should have a large input impedance. You can add a few more stages of gain so that the stations can be heard comfortably. Too much gain is a bad thing (why?)

Testing

Which AM stations are you receiving? Do you observe anything weird?

A test AM signal will provided in class, with a carrier frequency of 1MHz and a message frequency of 1KHz.

The carrier frequency can be varied by the TA under special conditions if you need to verify the range of operation of the circuit. We do not have the resources to provide each bench with a special signal generator.

Record the waveforms at every point with the test signal. sketch and see if you get waveforms described in this report.

We will also broadcast RADIO EE which had the music of the TA’s choice. Try to tune in.

Make suggestions to improve the sensitivity of your radio?

Why are present radios so complicated? What limitations of the your design do they overcome?

3.5 Lab notebook

Record all your observations and the techniques you used to improve your sensitivity. Make a note of what radio stations you were able to receive.

3.6 Lab Report

Your lab report should contain all of the lab results (data, graphs, drawings, etc.) It should be a self-contained self-explanatory report. It should be more than a list of answers to the questions in the lab notes. Your comments on the results should reflect your understanding of the lab exercises. Your well thought out reasoning and analyses of the experimental results will be appreciated and reflected in your grade. The report need not be typed or prepared with a word processor, however, points will be deducted for a sloppy, un-professional report.

Appendix

A.1 Diode Polarity,

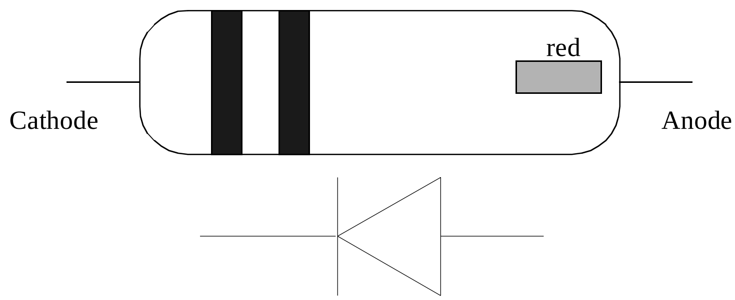


Figure 3.5—.Diode (1N34) Connections

A.2 Tuning Coil

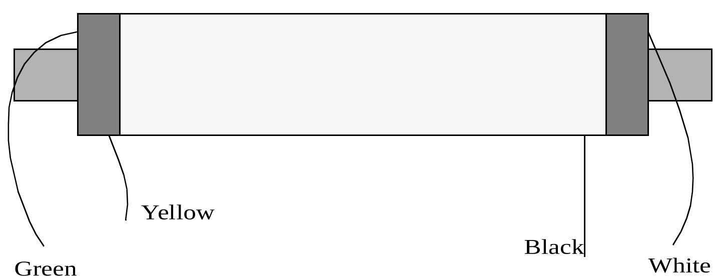


Figure 3.6—Schematic of the Medium Wave Coil

Parts List

Medium Wave Tuning Coil

Variable Capacitor (50-500pF)

1N34, Germanium diode

(3) LM741 Operational Amplifiers

1 small PC board

Miscellaneous components like Antenna wire, soldering iron etc.

Resistors

Capacitors

APPENDIX

RF PROBE

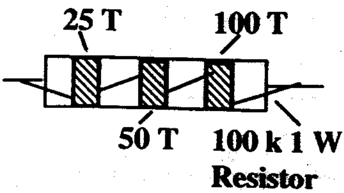
RF probe is an unavoidable instrument during the assembling , testing and alignment of a transmitter . Here is a simple circuit of RF probe that can be constructed very easily . The circuit is so simple that only four components are used for it's construction .

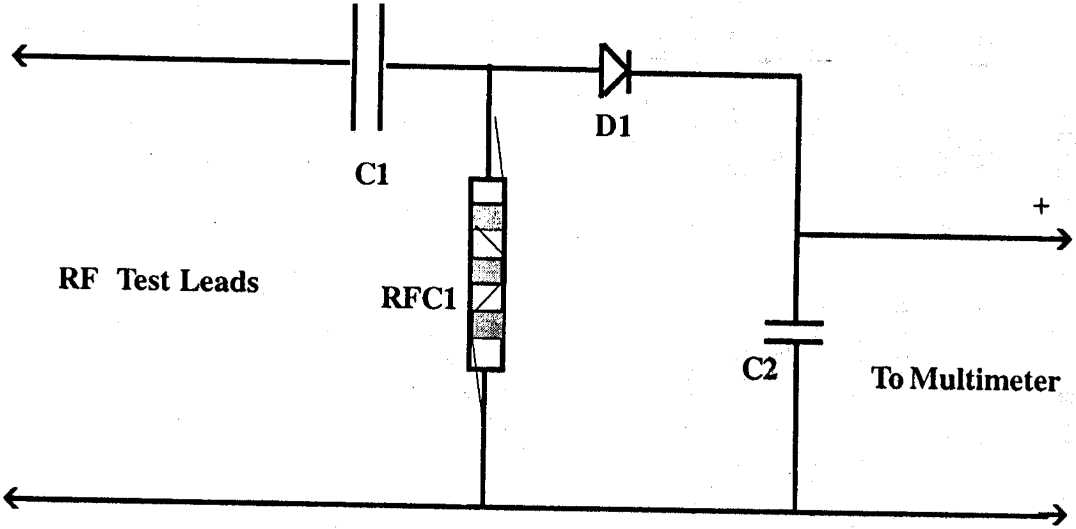
A multimeter is connected to it and used for measuring the RF signal strength .The multimeter should be in a suitable voltage range , say 6 or 10 V DC .

The test leads should be of minimum length . A length of about 10 cm will be appropriate Using crocadile pins at the lead ends will helps to attach the leads at the test points easily . The circuit can be assembled in a general purpose PCB . The component list and construction details of the RFC is given below .

COMPONENT DETAILS OF RF PROBE

No.	Item ID.	Description .
1.	C1	.01 uf
2.	C2	.01 uf
3.	D1	OA 79
4.	RFC 1	The RFC can be made by winding 175 turns of 36 S.W.G. enamelled copper wire on a 100 K ohms / 1 watt resistor sectioned as shown in the figure aside..





CIRCUIT DIAGRUM OF RF PROBE

Back to Projects Page! Home!

Homebrew A 4 To 1 Balun
By N1HFX

Many modern HF transceivers come fully equipped with built in tuners. While these tuners are great for changing bands, the manufacturers left out a very important accessory; the 4 to 1 balun. With out a balun the transceiver can only feed an antenna which uses coaxial cable. While this may be satisfactory for some operators, this is a real problem for those of us who prefer the super low loss ladder line. The only other alternative is to buy an external tuner with a built-in balun which is really absurd after spending the additional money to have one built into the radio. Fortunately, a 4 to 1 balun can be easily home brewed as illustrated in Figures 1 and 2.

Figure 1 shows a bifilar winding on a toroid. The toroid should be type 2 (red) material and can be any of the following sizes but the number of bifilar turns should be adjusted accordingly:

TOROID	NUMBER OF TURNS	POWER RATING
T80-2	25	60 Watts
T106-2	16	100 Watts
T130-2	18	150 Watts
T157-2	16	250 Watts
T200-2	17	400 Watts
T200A-2	13	400 Watts
T400-2	14	1000 Watts

The exact number of turns is not critical but the numbers listed in the preceding table should yield optimum results. It is possible to exceed the power ratings listed above but the performance of the balun may be degraded during high SWR causing heating of the core.

Toroids of this type are available from Palomar Engineers, P.O. Box 462222, Escondido, CA 92046 (1-800-883-7020). If enough inquires are made, the author will make a limited number of toroids available at RASON meetings for those who hate mail order. The author will even wind the toroid for the faint of heart.

The balun should be housed in a suitable metal enclosure such as those available at Radio Shack. Use a SO239 or BNC connector for the unbalanced input. Nylon binding posts such as RS 274-662 work just fine for the balanced output.

DE N1HFX

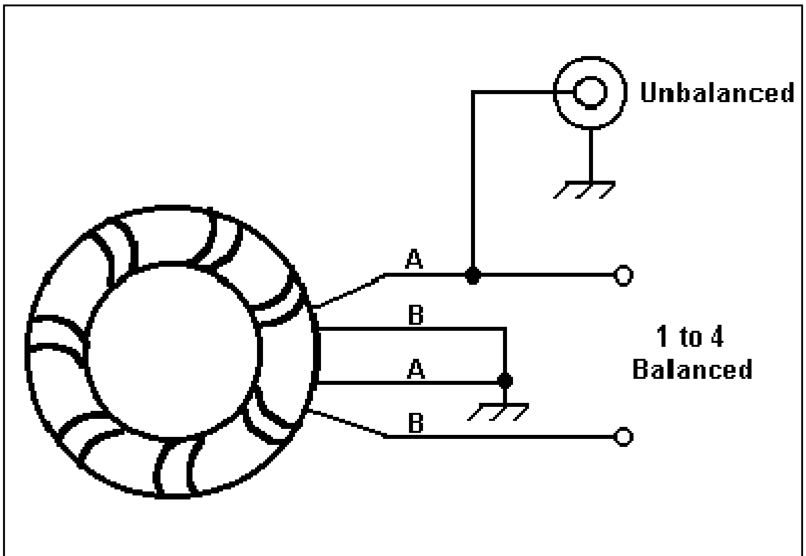


Figure 1

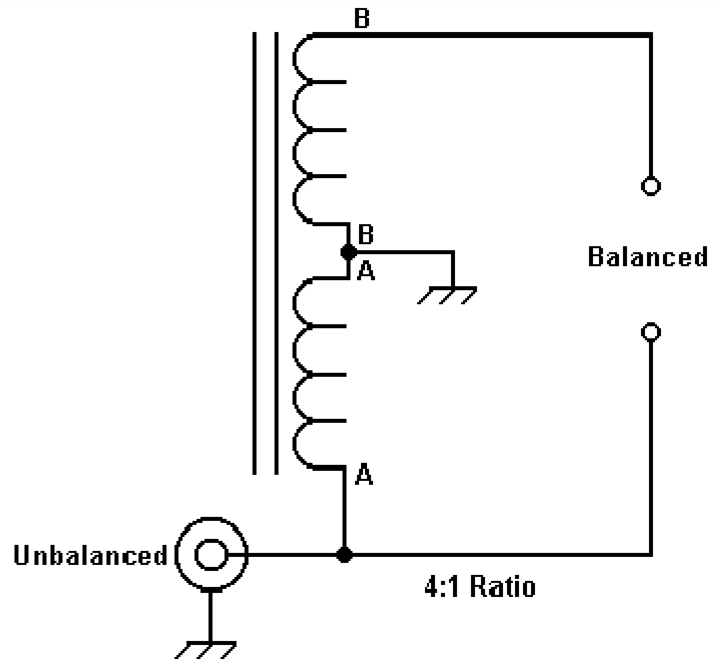


Figure 2

[Back to Projects Page!] [Home!]

APPENDIX

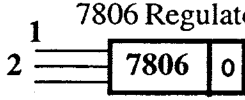
POWER SUPPLY FOR V.F.O

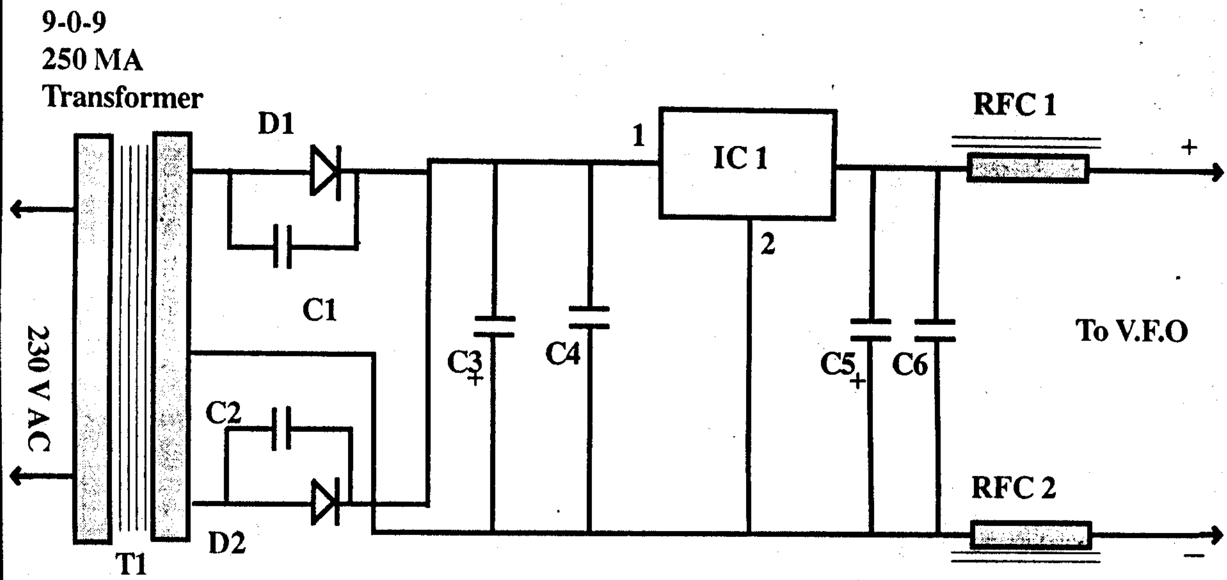
The best source of power supply to the VFO is from the battery . But it may not be practical at many situations . So a well filtered power supply circuit can be used for providing power to the VFO . Such a circuit is given here .

The circuit mainly consists of a regulator build around IC 7806 . Use a good heat sink for the IC . The power supply should not be placed inside the VFO box . Fix the power supply in a eliminator box or metal box and keep it away from the VFO .

The component details and construction of the RFC is given below .

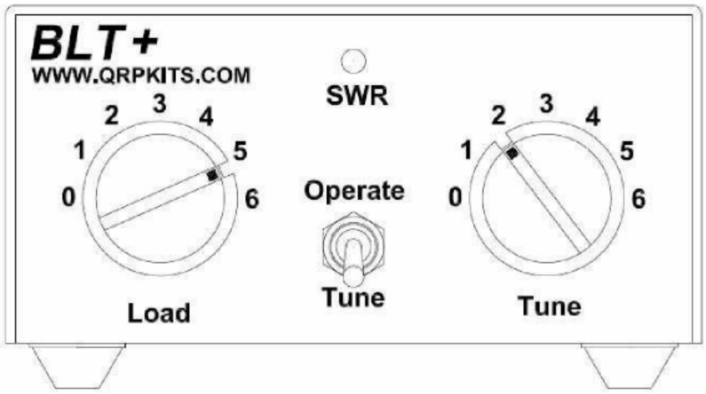
COMPONENT DETAILS

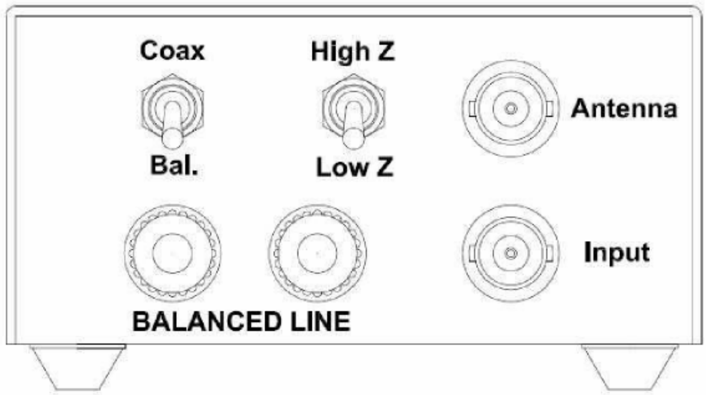
No.	Item ID.	Description
1.	C1	.1 uf
2.	C2	.1 uf
3.	C3	1000 MFD , 16 V
4.	C4	.1 uf
5.	C5	220 MFD , 16 V
6.	C6	.1 uf
7.	D1	IN 4001
8.	D2	IN 4001
9.	IC1	7806 Regulator 
10.	RFC 1 & RFC 2	RFC can be constructed by wind- 10 or 20 turns using a 34 SWG on TV balun core or toroid .



CIRCUIT DIAGRUM OF V.F.O POWER SUPPLY

BLT+ decal Installation





The decals are applied the same as model decals. Cut around each group of text or symbols you wish to apply, leave a border. It doesn't have to be perfect as the background film is transparent. Apply the decals before you mount anything to the cover. Use the above 1:1 picture to get the correct spacing around the holes and cutouts, as it is very easy to do a great decal installation and have a portion covered up with a knob

Thoroughly clean the surface of the panel to remove any oils or contamination. We have found that decal installation on bare brushed aluminum chassis prevents moving the decals into position, so we advise pre-coating the chassis with the Krylon clear before applying the decals.

Trim around the decal, leaving about 1/16" space around the printing. After trimming place the decal in a bowl of lukewarm water, with a small drop of dish soap to reduce the surface tension, for 10-15 seconds. Handle carefully to avoid tearing. Start to slide the decal off to the side of the backing paper, and place the unsupported edge of the decal close to the final location. Hold the edge of the decal against the panel, with your finger, and slide the paper out from under the decal. You can slide the decal around to the right position, as it will float slightly on the film of water. Use a knife point or something sharp to do this. When in position, hold the edge of the decal with your finger and gently squeege excess water out from under the decal with a tissue or paper towel. Work from the center, to both sides. Remove any bubbles by wiping gently to the sides. Do this for each decal, and take your time. Allow to set overnight, or speed drying by placing near a fan for a few of hours. When dry, spray two **light** coats of matte finish, Krylon, clear to seal and protect the decals, and allow to dry in between coats. All decals come with two complete sets, in case you mess one up.

APPENDIX

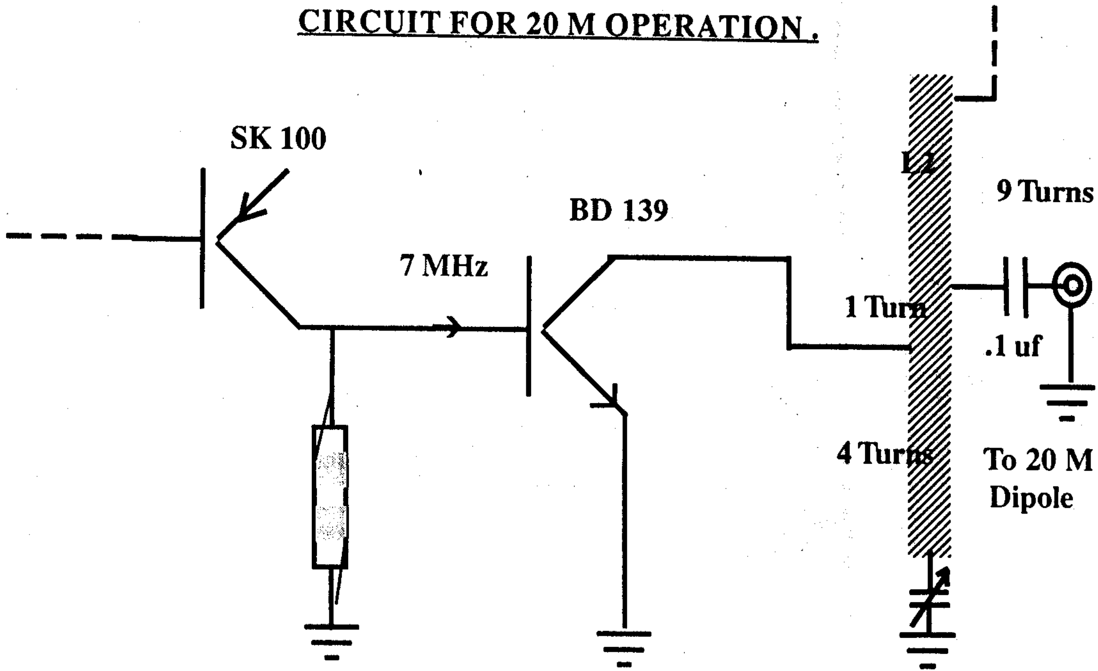
MODIFICATION FOR 20 M OPERATION.

Even though the VU2 VWN transmitter was deigned to operate on 40 M , it can also be made to operate at 20 M band by a simple modification in the RF coil . The Changes that had to be made in the coil is given below. The part of the circuit with modified coil is given in the fig . All other stages remain the same with no modifications . Ofcourse , you have to change the anteena dimensions accordingly when switching between 40 M and 20 M .

Specification of coil L2 (1.6 uH)

Former diameter = 1.7 cm.
Winding length = 2 c.m.
S.W.G = 20/22
Total no. of turns = 14
Tap at 9th and 10th turns.

CIRCUIT FOR 20 M OPERATION .



QUASAR PROJECT KIT # 3063 - ONE-CHIP AM RADIO

This project is from our educational electronics series. It presents the building blocks of a modern day mini-sized AM radio receiver as found in key-rings, watches & palm-sized radios. They are:

- the Tuned Radio Frequency (TRF) front end
- a single chip AM radio IC, and
- amplification of the audio signal into a speaker

All these components are presented on a single printed circuit board so you can build and experiment with your radio. We have built the kit using standard passive components. Most commercial radios now use surface mount components which results in very small sized radios.

AM radio broadcasts consist of a radio frequency (RF) signal generated at a specific frequency allocated to a particular station. On this RF signal is superimposed an audio frequency signal. The audio frequency is said to Amplitude Modulate the radio frequency carrier.

AM RF signals of all frequencies are present all around us. Our radio must be able to be 'find' the station we want from all the thousands of signals present. It has to be able to tune into the desired radio station and exclude all other signals. And it must be able to tune into weak signals just as easily as tune into strong signals. Let us introduce two technical terms to describe these requirements.

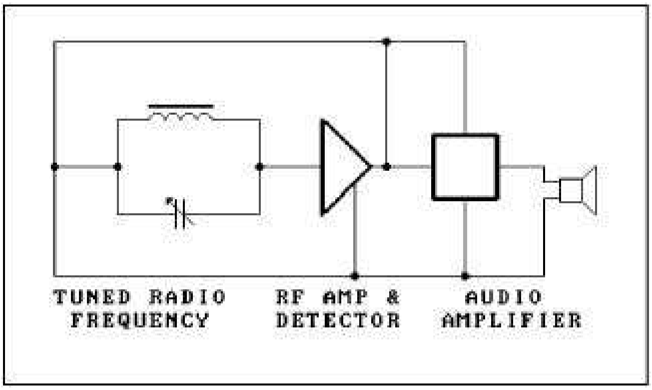
Sensitivity is the ability to pick up weak signals while keeping the background noise to a minimum.
Selectivity is the ability of a radio to tune into a particular station and reject all other stations.

For mini-radio users selectivity is usually the more important: teenagers listening to heavy metal, adults listening to the horse races, soap operas and the news. Most often the listener wants to be able to pick up all the local stations without any interference even though adjacent stations may be very close on the dial. Usually they are not much concerned with being able to detect distant AM signals say over 30 miles away.

1. The TRF Front End

This consists of two components, the ferrite aerial coil and the tuning capacitor. The important word is tuned. All the AM signals reaching the radio are very, very weak. Only that signal which matches the TRF frequency is magnified by resonance so that it stands out at a very much higher level of signal strength.

This kit uses a standard 60/160 AM Tuning Capacitor. t contains two film capacitors. Their capacitance changes as you turn the knob. We only use the 0 - 160pF capacitor for our radio. (The other 0 - 60pF capacitor is used in better quality AM radios that use regeneration on the aerial coil.) The centre pin is the common connection. Two screws on the top of the package adjust a trimmer capacitor associated with each capacitor. If you are unfamiliar with this item connect it to a capacitance meter and play with the main adjustment knob and the trimmer capacitors so you understand what is happening. In this radio the position of the trimmers is not relevant.



The second component of the TRF is the coil & ferrite bar. We supply the coil prewound with 90 turns of 3 strand Litz wire. We get these coils from a commercial manufacturer of these coils who supplies exactly the same item to AM radio manufacturers. Litz wire consists of many strands of fine enamelled wire twisted together with cotton to add strength. Litz wire has a significantly lower resistance to RF than a single wire and is used in virtually all commercial coils.

The ferrite bar increases the inductance of the coil. The two components connected in parallel form a LC network. The Litz wire of the coil and the ferrite bar give the network a high Q, or Quality factor. This is critically important for the selectivity of the radio, the ability to tune into one radio station only and not be able to hear several others at the same time.

The coil winding & the ferrite bar act as an efficient wire antenna. No additional external antenna is needed. The only disadvantage is that the tuned circuit is directional. Signal strength depends on the orientation of the bar with respect to the origin of the signal.

2. AM Radio ICMK484

It is important to realise that the radio IC does not create any sounds by itself. It can only take the RF signal provided from the TRF circuit, amplify it, separate the audio signal from the RF (called detection) and pass the audio signal on to be amplified. It has no selective or rejection components contained in it. (This is in contrast to superhetrodyne receivers.) The MK484 we use is a Japanese copy of the original ZN414. It contains an RF amplifier, active detector and automatic gain control (AGC to improve sensitivity) all in a 3-pin package. The input impedance is typically 4M ohm. It operates over a range of 150kHz to 3MHz. DC supply of 1.1V to 1.8V & 0.3mA current drain makes it ideal for battery operation. The output is typically 40 - 60 mV of audio signal. Optimal AGC is provided by R3 and C2 (see Figure 2). R3 (the AGC resistor) should be in the range 100R to 1.5K. A bandwidth of about 4kHz is achieved. The MK484 data sheet can be downloaded from our website at:

http://www.quasarelectronics.com/ds.htm

3. Audio Amplification

The audio signal output from the MK484 is too weak to drive a speaker directly. In this kit the signal is fed into two stages of amplification and then into a speaker. These are standard designs. The first is a transistor Class A amplifier.

QUASAR PROJECT KIT # 3063 - ONE-CHIP AM RADIO

The second is a Class AB amplifier. See our kit 3048 Introduction to Class AB Amplifiers for a description of how it works (a PDF file of 3048 is available on our website).

About Our Design
Our circuit is show below. You should be able to understand most of it from the above block descriptions. The two forward biased diodes D1 & D2 appear to short circuit the power supply to the MK484, but this IC only requires about 1.5V to operate and the combined forward drop of the 2 diodes is exactly right. We have provided the complete radio, excluding speaker, on a single PCB so that it is easy to experiment with. It can be modified to fit into a box.

Construction
Components can be added to the board in any order but it is usually best to add the lowest height components first i.e. the resistors and diodes.

Make sure you get the diodes (D1 – D4) and electrolytic capacitors (C3 & C8) around the correct way. The black bar on the diode corresponds to the bar on the overlay.

The BC548, BC558 and MK484 all come in a TO-92 style package. Identify each one and put them in their correct positions as shown on the overlay.

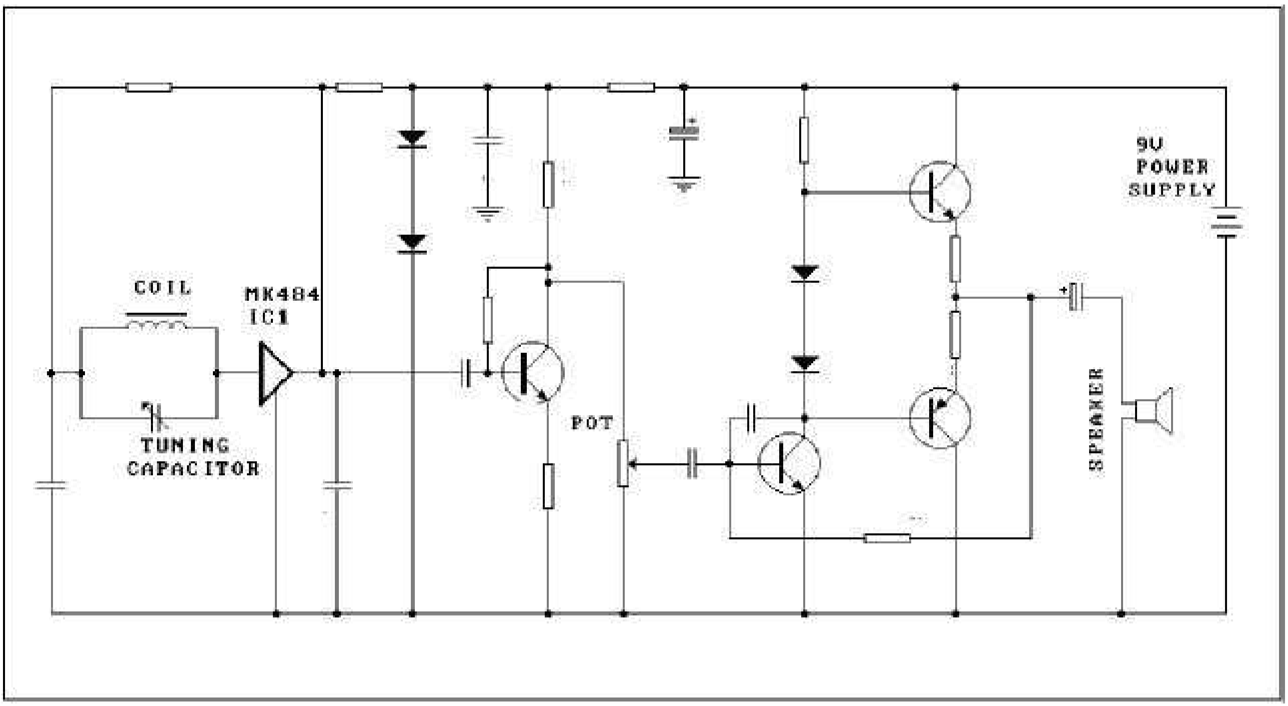
The tuning capacitor is mounted on the component side of the PCB and secured using the two short screws. Use the long screw to secure the brass extension rod to the main tuning cap shaft. The volume potentiometer is also mounted on the PCB and a spindle is provided. Mounting holes to tie down the aerial coil have also been provided. Use some glue to hold the ferrite rod securely in the coil.

If It Does Not Work. Check that the diodes are all in the correct way. Are the resistors in the right places. Check that the TO-92 packaged components are in their correct places and orientation.

Testing
We were pleasantly surprised at the quality of the radio reception achieved by this kit. You can experiment by changing the number of turns in the coil to shift the TRF range.

COMPONENTS

RESISTORS (1/4W 5% Carbon):			
6R8	R9, 10	blue grey gold	2
100R	R6	brown black brown	1
1K	R3	brown black red	1
4K7	R1	yellow violet red	1
5K6	R7	green blue red	1
10K	R4	brown black orange	1
100K	R2	brown black yellow	1
150K	R5	brown green yellow	1
820K	R8	grey red yellow	1
10K	VR1	log pot Piher	1
Spindle for VR1 pot			1
CAPACITORS:			
470p	C7	Ceramic (471)	1
470nF	C1, 4, 5, 6	Monoblock (474)	4
100nF	C2	Monoblock (104)	1
100uF	C3, 8	elcap	2
60/160 AM tuning cap			1
Screws securing for tuning cap			2
Brass extension for tuning cap			1
Screw for extension for tuning cap			1
1N4148	D1, 2, 3, 4	diode	4
BC548	Q1, 2, 3	NPN transistor	3
BC558	Q4	PNP transistor	1
MK484	IC1	AM radio IC	1
2 pole terminal block			2
Coil & ferrite bar set			1
0.3 to 1W 8 Ohm speaker			1
Kit 3063 PCB			1
Documentation			1



5.4.4 设计实例

在下面的实例中，我们将按照上一小节介绍的步骤设计一个特定的滤波器。

例题 5.6 耦合微带线带通滤波器设计

设计一个耦合传输线带通滤波器，要求其带内波纹 3 dB，中心频率 5 GHz，下边频、上边频分别为 4.8 GHz 和 5.2 GHz。在 5.3 GHz 频率点的衰减大于 30 dB。求该滤波器的元件数目及耦合传输线的奇模、偶模特性阻抗。

解：根据 5.4.3 小节，滤波器设计的第一步是选择适当的低通滤波器原型。滤波器的阶数可以根据 5.3 GHz 频率点的衰减大于 30 dB 的要求确定。利用带通滤波器的频率变换公式(5.46)，在 5.3 GHz 频率点，可以求出低通滤波器原型的相应归一化频率为：

$$\Omega = \frac{\omega_c}{\omega_U - \omega_L}\left(\frac{\omega}{\omega_c} - \frac{\omega_c}{\omega}\right) = 1.476\ 4$$

根据图 5.21 可知，要在 $\Omega = 1.476\ 4$ 频率点获得 30 dB 的衰减，滤波器的阶数至少为 $N = 5$。已知具有 3 dB 波纹的 5 阶切比雪夫滤波器的元件参数为：

$$g_1 = g_5 = 3.481\ 7, g_2 = g_4 = 0.761\ 8, g_3 = 4.538\ 1, g_6 = 1$$

下一个设计步骤是根据公式(5.74)求出耦合传输线的奇模、偶模特性阻抗。计算结果见下列表格。

i	$Z_0 J_{i,i+1}$	$Z_{0o}(\Omega)$	$Z_{0e}(\Omega)$
0	0.190 0	42.305 6	61.303 7
1	0.077 2	46.439 7	54.155 7
2	0.067 6	46.849 1	53.607 7
3	0.067 6	46.849 1	53.607 7
4	0.077 2	46.439 7	54.155 7
5	0.190 0	42.305 6	61.303 7

为了验证理论设计的正确性，可以采用 MMICAD 对设计好的带通滤波器特性进行模拟、分析，结果如图 5.49 所示。

图 5.49 所示的滤波器响应证实了滤波器特性符合 f_L 和 f_H 的技术要求，而且在 5.3 GHz 频率点的衰减超过了 30 dB。

通常，滤波器设计的理论参数需要采用射频电路模拟方法再次验证其真实特性。

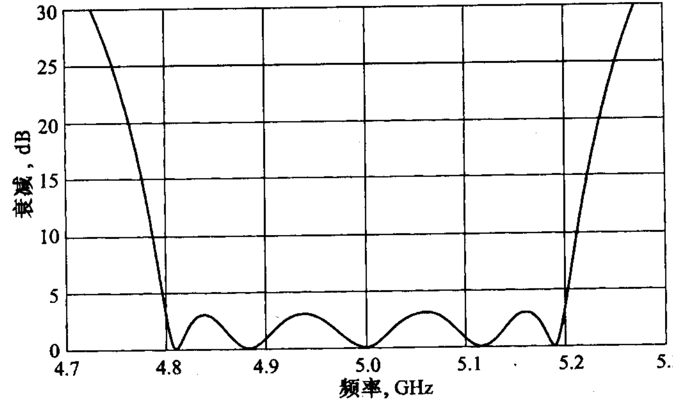


图 5.49 用 MMICAD 模拟通带波纹为 3 dB 的 5 阶耦合传输线切比雪夫滤波器。下边频为4.8 GHz,上边频为5.2 GHz

我们借助于模拟软件的另一个原因是:我们需要从另一个角度检验滤波器设计方法的正确性并且考察几何尺寸和介质特性变化对滤波器性能的影响。上述参量中的大多数都很容易利用计算机来研究。完成了初步理论设计方案后,通常是利用计算机模拟来进行实际电路布线和实验的。

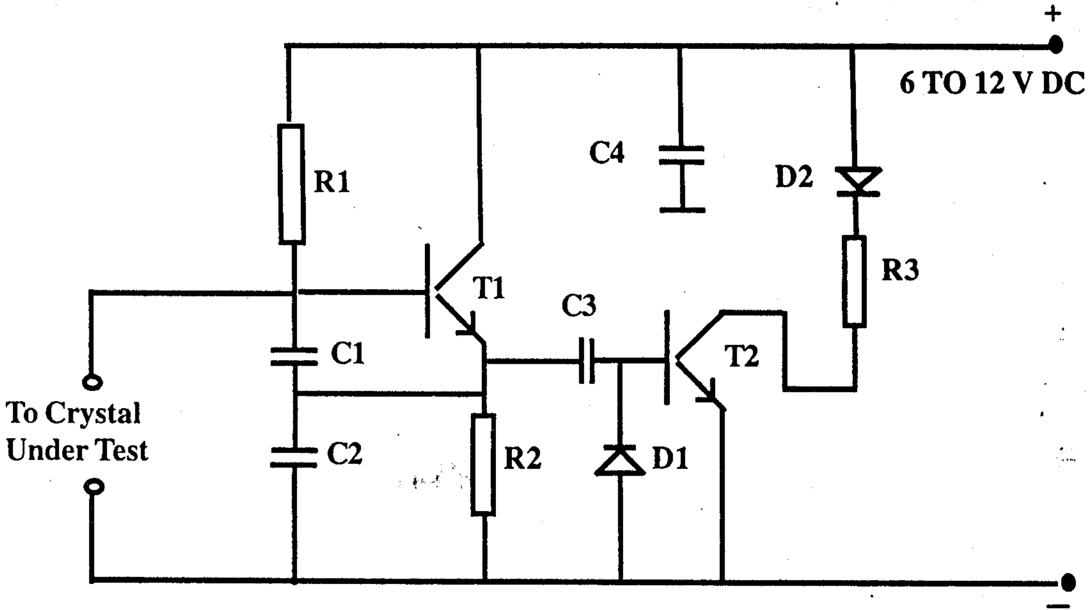
APPENDIX

CRYSTAL TESTER

Crystals are essential part of ham radio equipments. Crystals cannot be tested using a multimeter. So we are proving here a circuit of crystal tester. The LED will indicate whether the crystal under test is O.K or not. The circuit is given in the next page. The component details are given below.

COMPONENT DETAILS FOR CRYSTAL TESTER

No.	Item ID.	Description.
1.	R1	100 K
2.	R2	2.2 K
3.	R3	330 OHM
4.	C1	220
5.	C2	220
6.	C3	100
7.	C4	0.1
8.	D1	IN 4148
9.	D2	LED
10.	T1	BC 547
11.	T2	BC 548



CIRCUIT DIAGRAM OF CRYSTAL TESTER

GLOSSARY

HAM RADIO TERMS

Icom Inc.

This is glossary contains general definitions of typical amateur radio terms. Not all of the definition listed may apply to your specific model of radio. Consult the manufacture for further clarification of model-specific terms.

A

ACC (ACCessory)

Adjacent-channel interference
When a receiver is tuned to a specific frequency and interference is received on a nearby frequency.

AF (Audio Frequency)

AFC (Automatic Frequency Control)
Automatically compensate frequency drift.

AFSK (Audio Frequency Shift Keying)

AGC (Automatic Gain Control)
Automatically optimize receiver amplifier gain.

ALC (Automatic Limiting Control)
Limits RF drive level to power amplifier during transmit to prevent distortion.

AM (Amplitude Modulation)

AMSAT (AMateur SATellite)

AMTOR (AMateur Teleprinting Over Radio)
A form of RTTY, radio teletype.

ANF (Automatic Notch Filter)

ANL (Automatic Noise Limiter)
Eliminates impulse and static noise peaks.

ANT (ANTenna)

Antenna ground system
Term used for a RF reference potential for some types of antennas. Most unbalanced or asymmetrical antennas need a good RF ground.

Antenna impedance
The impedance of an antenna at its resonance. Although an antenna's impedance fluctuates with the frequency of operation, an antenna should be 50 Ω for most transceivers.

Antenna matching
When the antenna's impedance at resonance is at optimum performance for your transmitter output circuit.

Antenna tuner
Device used to match an antenna to the output impedance of a transmitter.

APC (Automatic Power Control)
Current limiting of power amplifier to prevent damage to finals in high SWR conditions.

APRS (Automatic Position Reporting System)
In conjunction with a GPS and TNC provide position reporting.

ARES (Amateur Radio Emergency Service)
ARES is a public-service organization of the ARRL.

ARRL (The American Radio Relay League
The National Association for Amateur Radio in the US.

ASCII (American National Standard Code for Information Interchange)
A seven-unit digital code for the transmission of teleprinter data.

ATT (ATTenuator)
A network designed to reduce the amplitude of a signal.

ATV (Amateur Television)
FSTV, SSTV

Auto patch
Used in repeater operation for telephone interconnect.

Average power
Power measured on standard power meter.

B

Backscatter
Form of ionosphere propagation via the E and F layers allowing stations to hear other stations within the skip zones.

Balun
A simple transformer used to change an unbalanced input to a balanced output.

Band
A range of frequencies.

Bandwidth
Frequency needed for particular type of emission.

Bank
Memory bank

BCI (BroadCast Interference)

BFO (Beat Frequency Oscillator)

BNC (Bayonet Neill-Concelman)
A type of antenna connector

BPF (BandPass Filter)

Busy lockout
Inhibits transmit on a frequency in use

C

Call sign
Sequence of letter and numbers used to identify amateur radio operators and issued by the FCC.

CAP (Civil Air Patrol)
Volunteer affiliate of the United States Air Force.

Carrier
An unmodulated transmitted signal.

Carrier frequency offset (=Carrier Shift)
Distance between mark and space of the carrier for RTTY or similar communications.

CBR (Cross Band Repeater)
A repeater which receive incoming signal and re-transmit it in different bands— e.g. receives 144 MHz bands and re-transmits 430(440) MHz bands.

CCW (Counter ClockWise)

CH (CHannel)
Sequence of memory positions where frequency and related information is stored.

CI-V
Icom computer Control Interface allows multiple radio control simultaneously.

Conversion
Number of IF circuits in the receiver.

CPU (Central Processing Unit)

CQ
Radio communications term used to call others.

CTCSS (Continuous Tone Coded Squelch System)
Adds a continuous sub-audible low frequency tone to the transmitted carrier. Receivers set for the same low frequency tone can decode signal.

CW
1) Carrier Wave
2) ClockWise

CW filter
Used to narrow IF passband to improve reception in crowded band conditions.

D

Data communications
Transfer of data between two or more locations.

dBd
Unit of RF power as compared to a dipole antenna.

dBi
Unit of RF power as compared to an isotropic antenna.

dBm
Decibels measure, 1 mW with a load impedance of 600 Ω (0 dBm=1 mW).

DC (Direct Current)

DC ground
A connection point directly to chassis or battery ground to prevent build-up of hazardous DC voltages.

Deviation
A measurement for a FM signals for the maximum carrier frequency changes either side of the carrier frequency.

Distress call
Signals a life-threatening situation. Most commonly referred to as an SOS or MAYDAY call.

Distress frequency
A frequency or channel specific for use in distress calling. Radiotelephone distress frequencies are 2.182 MHz and 156.8 MHz. Survival craft use 243 MHz. Maritime distress frequencies are the same, while general aviation frequencies are 121.5 MHz.

Downlink (↔Uplink)
Frequency that repeater or satellite transmits on to a user.

DSP (Digital Signal Processor)
Used to improve the signal to noise ratio for clearer and more legible communications. Relatively new to the ham radio.

DTCS (Digital Tone Coded Squelch)
A Selective call system

DTMF (Dual Tone Multi-Frequency (=touch-tone))
Used for transmit/receive numeric information such as phone number, PIN, remote radio control commands etc.

Dualwatch
Receiving two signals simultaneously.

Dummy load
A non radiating 50 Ω load connected to the transmitter to replace the antenna for testing purposes.

Duplex
An operation mode in which the transmit and receive frequencies are different.

Duplexer
A device which divides transmit and receive signals.

Duty cycle
The ratios of transmit to receive time.

Dx'pedition
Trip to foreign land to "be DX."

E

EBS (Emergency Broadcast System)
A system where at first an attention tone is transmitted over all station ad the second tone followed with specific instruction regarding the receivable frequency in the national emergency.

EEPROM (Electrically Erasable and Programmable Read Only Memory)

EME (Earth-Moon-Earth)
Moon bounce communication.

EMI (Electro-Magnetic Interference)
Often called RFI (Radio-Frequency Interference).

Emission
Transmission of a signal

Encryption
Transmitting cryptic form so that only certain people understand what has been sent.

F

Fading
Signal reduction due to atmospherics.

Filter
A circuit designed to pass only the desired frequency(s).

FM
1) Frequency Modulation
2) FM broadcast

FSK (Frequency Shift Keying)

FSTV (Fast Scan TV)
Graphics (and audio) communication using TV broadcast signals, requires a wide bandwidth.

Full duplex
An operation mode, which transmits and receives on different frequencies at the same time, as a telephone communication.

G

Ground Plane
A type of Omni-directional antenna

Ground Wave
Electrical wave directly travelling from transmitter.

Grounding
Electrical connection to the earth.

H

Harmonic
Multiple of a fundamental frequency.

HF (High Frequency)
3–30 MHz range signals. (Normally, 1.9 MHz band also included.)

HPF (High Pass Filter)

Hz (Hertz)

I

IC (Integrated Circuit)

IF (Intermediate Frequency)
Internally converted frequency for amplification and other signal processing.

IF shift
A function that electronically shifts IF frequency from a center frequency.

IMD (Inter-Modulation Distortion)
Distortion within RF circuits made with upper and lower adjacent channel signals.

L

LF (Low Frequency)
30–300 kHz range signals.

Li-Ion (Lithium Ion)
Rechargeable battery which has better capacity than Ni-Cd, Ni-MH, etc., no memory effect after repeated non-full charge/discharge cycles.

LPF (Low Pass Filter)

LSB (Lower Side Band)

M

MARS (Military Affiliate Radio Service)

Memory bank
A set of memory channels organized into a group.

Memory effect
Rechargeable batteries such as Ni-Cd and Ni-MH types may be temporality getting less capacity as a result of repeated non-full charge/discharge cycles. It is called so since rechargeable batteries lose capacity as if “memorize” wrong full capacity level at less than full charge. Li-Ion batteries are free from this effect.

MF (Medium Frequency)
300 kHz–3 MHz range signals

MIC (MICrophone)

Modulation
Method of adding information to a radio frequency carrier

N

NB (Noise Blanker)
A function reducing pulse-type noises.

NBFM (Narrow Band FM)

Ni-Cd (Nickel-Cadmium)

Ni-MH (Nickel-Metal Hydride)

Notch filter
Sharp and narrow rejection filter for elimination of interfering signals

NR (Noise Reduction)
DSP feature reduces unwanted signal noise

O

Offset frequency
Frequency difference between transmits and receives.

OSC (OSCillator)

P

PA (Power Amplifier)

Parawatch (=Dualwatch)

PBT (PassBand Tuning)
A function electronically reduce interference by narrowing IF bandwidth

PEP (Peak Envelope Power)
RF power at maximum amplitude.

PLL (Phase Locked Loop)
Circuit to synthesize the different frequencies a radio will operate on.

Pocket beep
Beeping function when specific signal is received.

Priority watch
Reception mode, which by a selected frequency is always periodically, checked when VFO is set to different frequency

PTT (Push To Talk)

PWR (PoWeR)

R

Reflected power
Non-radiated power dissipated as heat when the transmitter is mismatched to the antenna or load.

Repeater
Radio systems, which receive incoming signal and re-transmit it for extended communication area. Normally put on geographically high locations for VHF/UHF hand portables.

RF (Radio Frequency)

RF ground
Connection of amateur equipment to earth ground to eliminate hazards from RF exposure and reduce RFI.

RFI (Radio Frequency Interference)

RIT (Receiver Incremental Tuning)
Fine-tuning receive frequency without changing displayed or memory frequency.

RTTY (Radio TeleTYpe)

RX (Receive)

S

S/N (Signal to Noise ratio)

SAR (Search And Rescue)

Scan
Continually sweeping frequencies looking for signals.

Scan Edge
End and start frequencies for a scanning range.

Scratch Pad Memory
Temporary frequency memories for quick access.

Semi Duplex
An operation mode in which transmits and receives is accomplished on different frequencies alternatively.

Sensitivity
Indicates how weak a signal the receiver will pick up.

Set mode
An operation mode used for radio. To set less frequently used control features.

Simplex
An operation mode where transmit and receive frequency is same.

Skywarn
Trained volunteer storm spotters for the National Weather Service.

SMA (Sub-Miniature a connector)
Type of antenna connector, used in VHF/UHF portable.

SP (SPeaker)

Split
A mode in which the transmit and receive frequency is different.

SQL (SQueLch)
A function muting audio output for set conditions.

SSB (Single Side Band)

SSTV (Slow Scan TV)
Graphics communication using narrow bandwidth.

SWL (Short Wave Listener)

SWR (Standing Wave Ratio)
Measurement of forward vs. reflected power output during transmit.

T

TCXO (Temperature Compensated Crystal Oscillator)
Heated crystal oscillator for better frequency stability.

TNC
1) Terminal Node Controller
Modem for data communication.
2) A type of antenna connector

TOT (Time Out Timer)
Time limiting function for continued repeater or other operations.

TS (Tuning Step)
Incremental steps

TSQL (Tone SQueLch)
Squelch function using subaudible tones, selective call.

TVI (TeleVision Interference)

TX (Transmit)

U

UHF (Ultra High Frequency)
300 MHz–3 GHz range signals.

Uplink (↔Downlink)
Frequency that user transmits to the repeater or satellite.

USB (Upper Side Band)

UTC (Universal Time Coordinated)
An astronomical time based on the Greenwich meridian (zero degrees longitude).

V

VFO (Variable Frequency Oscillator)
An operation mode in which operator can change frequency freely.

VHF (Very High Frequency)
30–300 MHz range signals.

VOX (Voice Operated transmission)
A function automatically put the transmitter in transmit when talk into a microphone.

VSC
1) Voice Scan Control
2) Voice Squelch Control

W

Weather Alert

NOAA broadcast station transmitting alert signals.

WFM (Wideband FM)

Number/Others

Count on us!

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STANDARD ANTENNA TERMS AND RELATED FORMULAS

The "IEEE Standard Definitions of Terms for Antennas" (IEEE STD-145) represents a consistent and comprehensive vocabulary suited for the effective communication and understanding of antenna theory. General use of these definitions of terms would eliminate much of the wide-spread inconsistency concerning antenna characteristics, particularly with regard to the basic parameters of gain, beamwidth, polarization and efficiency. For convenience, IEEE antenna terms of general interest are listed here. Wherever these terms appear in this catalog, the definitions given below apply. Other commonly used terms, not covered by the IEEE standard, are shown with an "*."

ANTENNA APERTURE. A surface, near or on an antenna, on which it is convenient to make assumptions regarding the field values for the purpose of computing fields at external points. **Note:** The aperture is often taken as that portion of a plane surface near the antenna, perpendicular to the direction of maximum radiation, through which the major part of the radiation passes.

ANTENNA EFFICIENCY OF APERTURE - TYPE ANTENNA. For an antenna with a specified planar aperture, the ratio of the maximum effective area of the antenna to the aperture area.

*** ANTENNA FACTOR.** That quantity by which the voltage developed across the output of an antenna is related to the incident field strength in which the antenna is immersed. **Note:** Applicable to low frequency antennas and usually refers to a 50 ohm output.

$$\mathrm{AFE\ (dB\ m^{-1}) = E\ (dB\ V/m)\ -\ V\ (dB\ V)}$$

AFE = Electric Field Antenna Factor
E = Electric Field Strength at antenna
V = Voltage at terminals of antenna

$$\mathrm{AFH\ (dB\ AV^{-1}\ m^{-1}) = H\ (dB\ A/m) - V(db\ V)}$$

AFH = Magnetic Field Antenna Factor
H = Magnetic Field Strength at antenna
V = Voltage at terminals of antenna

$$\mathrm{AFE\ (dB\ m^{-1})\ =\ AFH\ (dB\ AV^{-1}\ m^{-1}) + 51.53}$$

for a plane wave in free space.

$$\mathrm{AFB\ (dB\frac{pT}{\mu V})\ =\ B\ (dBpT)\ -\ V_o(dB\mu V)}$$

AFB = Magnetic flux Antenna Factor
B = Magnetic flux at the antenna
pT: picoTesla units
V = Voltage at the terminals of the antenna

$$\mathrm{AFB\ (dB\frac{pT}{\mu V}) = AFH\ (dB\frac{A}{Vm})\ + 2}$$

APERTURE ILLUMINATION. The field over the aperture as described by amplitude, phase, and polarization distributions.

APERTURE ILLUMINATION EFFICIENCY. For a planar antenna aperture, the ratio of its directivity to the directivity obtained when the aperture illumination is uniform.

BEAM. The major lobe of the radiation pattern.

CIRCULAR POLARIZATION. It may be either right hand circular polarization (RHCP) or left hand circular polarization (LHCP). The sense of polarization is determined by observation of the direction of rotation of the electric field vector from a point behind the source, RHCP and LHCP correspond to clockwise and counter-clockwise respectively. **Note:** RHCP transmit requires a like polarization to receive.

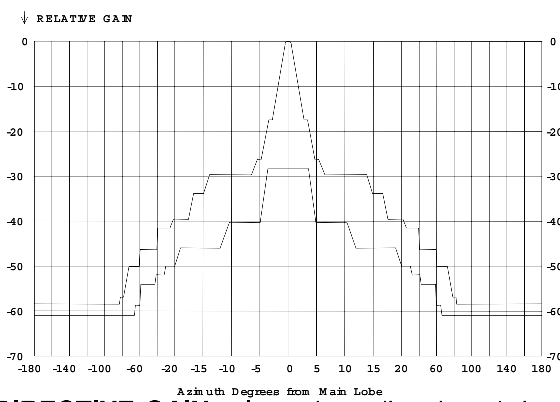
CO-POLARIZED. The polarization which the antenna is intended to radiate or receive. Also "like polarization".

*** CROSS POLARIZATION DISCRIMINATION (XPD).** Cross polarization discrimination is the measure of the antenna's ability to differentiate between the vertical and the horizontal polarization of an antenna. This difference, shown in relative signal level, is indicated on directional pattern envelopes (DPE's).

Antenna Research

STANDARD ANTENNA TERMS AND RELATED FORMULAS

*** DIRECTIONAL PATTERN ENVELOPES (DPE'S).** In accordance with standard practice, radiation characteristics in any given plane of polarization are measured and plotted using 360-degree polar coordinate systems. The resultant Directional Pattern Envelope is the smoothed composite of all these measurements. The purpose of these DPE's is to emphasize the worst composite condition.



DIRECTIVE GAIN. In a given direction, 4 times the ratio of the radiation intensity in that direction to the total power radiated by the antenna.

DIRECTIVITY. The value of the directive gain in the direction of its maximum value.

EFFECTIVE AREA OF AN ANTENNA. In a given direction, the ratio of power available at the terminals of a receiving antenna to the power per unit area of a plane wave incident on the antenna from that direction, polarized coincident with the polarization that the antenna would radiate.

FAR FIELD REGION. That region of the field of an antenna where the angular field distribution is essentially independent of the distance from a specified point in the antenna region.

*** FRONT-TO-BACK RATIO.** The ratio of the maximum directivity of an antenna to its directivity in a specified rearward direction.

*** Gain, dBi.** The gain expressed in decibels relative to an isotropic radiator that is linearly polarized.

$$G(dBi) = 10\log(G) \qquad G = 10^{\frac{G(dBi)}{10}}$$

*** GAIN, dBic.** The gain expressed in decibels relative to an isotropic radiator that is circularly polarized.

HALF-POWER BEAMWIDTH. In plane containing the direction of the maximum of a beam, the angle between the directions in which the radiation intensity is one half the maximum value of the beam.

HALF-WAVE DIPOLE. A half wavelength antenna, center fed so as to have equal current distribution in both halves. Mounted vertically, it has a doughnut shaped pattern, circular in the horizontal plane. It is an antenna that can be constructed. It has some inherent losses. When used as a gain reference, the half-wave dipole has a power gain of about 1.7 dBi.

*** ISOLATION.** Refers to the ability of one port of a dual polarized feed to discriminate against a signal fed into the other port.

ISOTROPIC RADIATOR. A hypothetical antenna having equal radiation intensity in all directions. Note: An isotropic radiator represents a convenient reference for expressing the directive properties of actual antennas.

NEAR-FIELD REGION. The spherical region of space between the antenna and the far field region.

NULL. The region of a radiation pattern, either computed or measured, where the amplitude goes through a minimum value. Note: (1) It represents the angular position where the phase or the far field pattern crosses the zero axis if the pattern is plotted as a phasor instead of a scalar value. Note: (2) The region outside the main beam of a directive antenna pattern consists of a series of minor lobes separated by nulls.

PARALLEL POLARIZATION. The condition where the electric vector is parallel to the local conducting surface. Note: Over the earth, this is usually referred to as being horizontal polarization.

PHASE CENTER. The location of a point associated with an antenna such that, if it is taken as the center of a sphere whose radius extends into the far-field, the phase of a given component over the surface of that radiation sphere is essentially constant, at least over the portion of the sphere where the radiation is significant.

STANDARD ANTENNA TERMS AND RELATED FORMULAS

POLARIZATION. The polarization of an antenna is defined as the polarization of the electromagnetic wave as described by the shape and orientation of an ellipse, which is the locus of the extremity of the field vector, and the sense in which the ellipse is traversed with time. The elliptical locus is called the polarization ellipse and the wave is said to elliptically polarized. Circular polarization and linear polarization are degenerate cases of elliptical polarization.

POWER DENSITY AT A POINT

$$S_{av} = \frac{GP_t}{4\pi r^2}$$

S_{av} = Time average power density in W/m^2
P_t = Power transmitted in watts
G = Antenna gain relative to an isotrope
r = Distance from antenna to point in meters

POWER DENSITY TO VOLTS/METER IN FREE SPACE

$$E^2 \text{ (V / m)} = 377\ S_{av} \text{ (W / m}^2\text{)}$$

$$S_{av} \text{ (W / m}^2\text{)} = E^2 \text{ (V / m) / 377}$$

$$1 \text{ V / m} = 2.65 \text{ mW / m}^2$$

POWER GAIN. In a given direction, 4 times the ratio of the radiation intensity in that direction to the net power accepted by the antenna from the connected transmitter. **Note:** (1) When the direction is not stated, the power gain is usually taken to be the power gain in the direction of its maximum value. (2) Power gain does not include reflection losses arising from mismatch of impedance.

POWER GAIN IN PHYSICAL MEDIA. In a given direction and at a given point in the far field the ratio of the power flux per unit area from an antenna to the power flux per unit area from an isotropic radiator at a specified location with the same power input as the subject antenna.

Note: The isotropic radiator must be within the smallest sphere containing the antenna. Suggested locations are antenna terminals and points of symmetry, if such exist.

POWER GAIN REFERRED TO A SPECIFIED POLARIZATION. The power gain of an antenna, reduced by the ratio of that portion of the radiation intensity corresponding to the specified polarization to the radiation intensity.

POWER TRANSMISSION FORMULAS

$$P_r = P_t \frac{G_t G_r \lambda^2}{(4\pi r)^2}$$

P_r (dB W) = P_t (dB W) + G_t (dBi) + G_r (dBi) - 20 log r - 20 log f + 27.56

P_r (dB W) = P_t (dB W) - AFE_t (dB m^{-1}) - AFE (dB m^{-1}) - 20 log r + 20 log f - 32

P_r = Power received
P_t = Power transmitted
G_r = Gain of receiving antenna
G_t = Gain of transmitting antenna
f = Frequency in MHz, λ = Wavelength
r = distance between antennas in meters
AFE_r = AFE of receiving antenna
AFE_t = AFE of transmitting antenna

RADIATOR. Any antenna or radiation element that is a discrete physical and functional entity.

RADIATION, ELECTROMAGNETIC. The emission of energy in the form of electromagnetic waves.

RADIATION INTENSITY. In a given direction, the power radiated from an antenna per unit solid angle.

RADIATION LOBE. A portion of the radiation pattern bounded by regions of relatively weak radiation intensity

RADIATION PATTERN (ANTENNA PATTERN). A graphical representation of radiation properties of the antenna as a function of space coordinates. **Note:** (1) In the usual case the radiation pattern is

determined in the far-field region and is represented as a function of directional coordinates. (2) Radiation properties include power flux density, field strength, phase, and polarization.

*** RADIATION RESISTANCE OF AN ELECTRICALLY SMALL LOOP ANTENNA.** The resistive component of an antenna's input impedance that results from the coupling of the antenna to its environment. This resistance dissipates the power that is actually radiated from the antenna.

$$R_r = 20\,(2\pi/\lambda)^4 n^2 A^2 \text{ ohms}$$

n = number of turns
A = area of the loop

REALIZED GAIN. The power gain of an antenna in its environment, reduced by the losses due to the mismatch of the antenna input impedance to a specified impedance.

*** REALIZED RADIATOR EFFICIENCY.** The efficiency of an antenna in its environment reduced by all losses suffered by it, including: ohmic losses, mismatch losses, feedline transmission losses, and radome losses.

RELATIVE POWER GAIN. The ratio of the power gain in a given direction to the power gain of a reference antenna in its reference direction. **Note:** Common reference antennas are half-wave dipoles, electric dipoles, magnetic dipoles, monopoles, and calibrated horn antennas.

RETURN LOSS. The reflection coefficient of a mismatch expressed in decibels. **Note:** Modern swept VSWR techniques actually sense the reflected component which is normalized to the forward component to yield return loss. A 2:1 VSWR is equivalent to 9.5 dB return loss.

VSWR. The voltage standing wave ratio of a component such as an antenna. It is referred to the characteristic impedance of the transmission line being used. **Note:** The most common characteristic impedance is 50 ohms, but 75 and 300 ohms are frequently used in coaxial or twin lines for VHF, UHF applications.

NOTES:

Phone: 301-937-8888 ● Fax: 301-937-2796 ● http://www.ara-inc.com ● sales@ara-inc.com

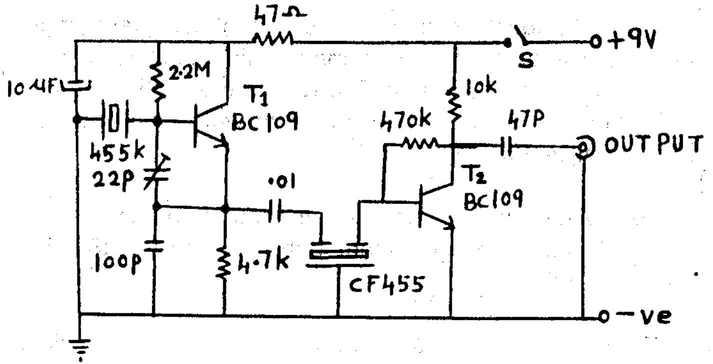
ROCKBOUND IF OSCILLATOR

By N. S. Harisankar

This Rockbound IF Oscillator can be very helpful when aligning or realigning an AM Superhet receiver.

T1 is used in a simple Rockbound OSC, and it operaters in the emitter follower mode. Ceramic filter CF 455 gives good frequency stability, requires no adjustment in order to produce the correct frequency.

The 455 Khz output from Oscillator is considerably amplified by a common emitter stage based on T2. This common emitter amplifier is high gain and low noise type. Use 6F22 (9 V) battery and Philips 22 PF Button Trimmer (Green Colour)



(The Author is N. S. Narishankar, Sankar Nilagam, Ambikapuram Palakkaed 678011 Kerala)

INSTALLATION

The relay box may be mounted on a tower leg, mast or building wall. The mounting hardware furnished will accept a tubular mast up to 1 ½” diameter.

If the box is mounted on a building wall discard the “U” bolt assembly and use two ½” screws to attach the bracket to the wall.

The relay box must be mounted with the connectors down. Do not attempt to air seal the relay box. Install drip loops below the box if the feedlines are brought in from a higher location. Lightning retarding loops area recommended precaution on all cables (see illustration).

Relay Box Cable Connections

Connect your antennas to coax connectors numbered 1-4 and note which antenna is connected to each socket.

Connect a coax lead to the connector marked “CONTROL CONSOLE.” This lead should be long enough to attach to the control console.

If control power fails, the relay box selects antenna “4”. It would thus be wise to put the most frequently used antenna in position 4.

Control Console Connections

Locate the RCS-4 control console at a convenient location on the station operating desk.

The control console supplies 12V AC and DC control voltages. It has an internal 1A fuse in the transformer secondary circuit that protects the power supply if a short circuit occurs in the feedline. Caution must be exercised when connecting the RCS-4 to prevent damage to station equipment.

Use coax to connect the “STATION” SO-239 connector to the output connector of your transceiver, amplifier or tuner. Connect the coaxial line from the relay box to the “RELAY BOX” SO-239 connector.

DO NOT CONNECT THE “RELAY BOX” CONNECTOR TO THE STATION. CONNECT IT TO THE RELAY BOX FEEDLINE ONLY. DO NOT “HOT SWITCH” THE RELAY BOX WITH POWER LEVELS OVER 100 WATTS.

THERE SHOULD BE NO PIECE OF EQUIPMENT BETWEEN THE INDOOR AND OUTDOOR BOX.

OPERATION

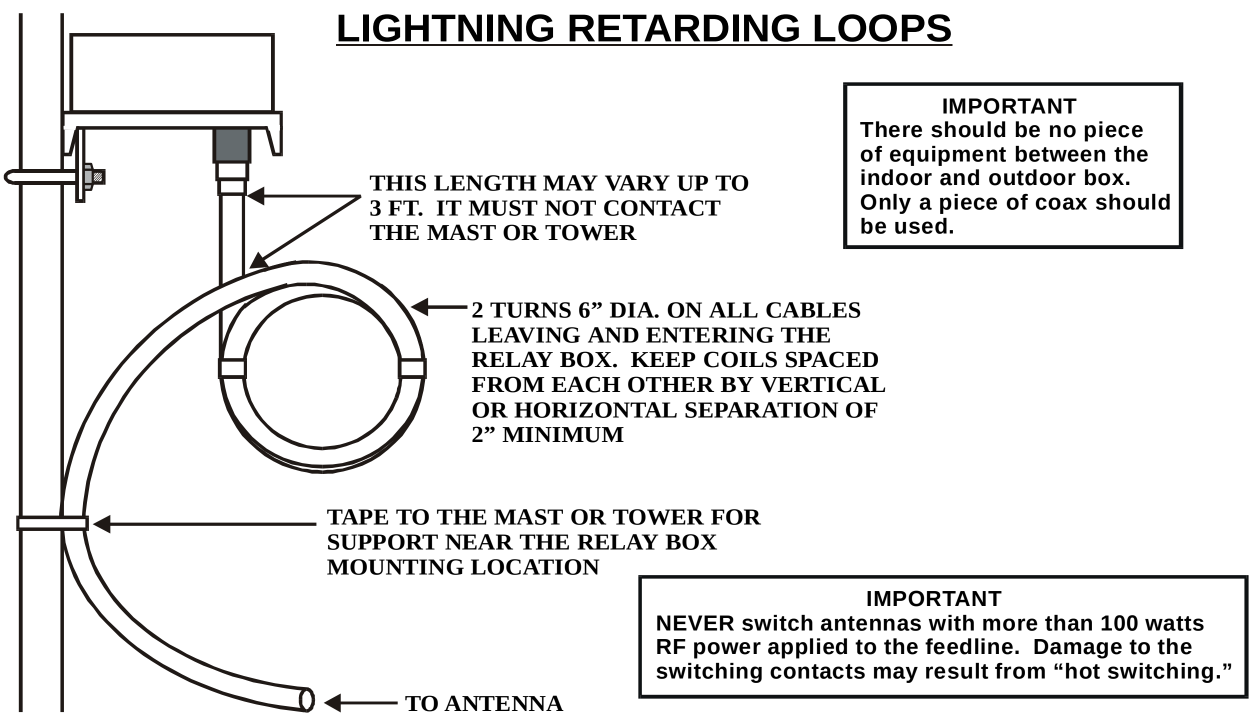
1. Plug the line cord into a 117 VAC outlet.
2. Place the PWR switch in the “ON” position.
3. Rotate the SELECT control and observe the lights one through four.

The switch positions are numbered on the front of the control box and a space is provided above each position so you can pencil in its designation for each antenna.

GROUNDING

The RCS-4 has small air gaps near each antenna connector on the printed circuit board to protect against lightning damage. We strongly recommend the use of lightning retarding loops in the coaxial cables near the relay box (see illustration). Remember that lightning travels through the path of least resistance. Station ground leads should be solid, large surface area conductors. Do not use braided or stranded wire for the ground leads. Avoid sharp bends in the ground leads. Use multiple ground rods and/or radials to provide the earth termination.

LIGHTNING RETARDING LOOPS



TECHNICAL ASSISTANCE

If you have any problem with this unit first check the appropriate section of this manual. If the manual does not reference your problem or reading the manual does not solve your problem, call *Ameritron* at **662-323-8211**. We can only help if you have your RCS-4 manual, radio manual, and information about your station available during the call.

We strongly recommend calling Ameritron with any questions, but questions can be mailed directly to Ameritron at 116 Willow Road, Starkville, MS 39759 or faxed to 662-323-9810. Be sure to send a complete description of the problem, explain how this unit is being used, and include a complete description of your station.

PARTS LIST

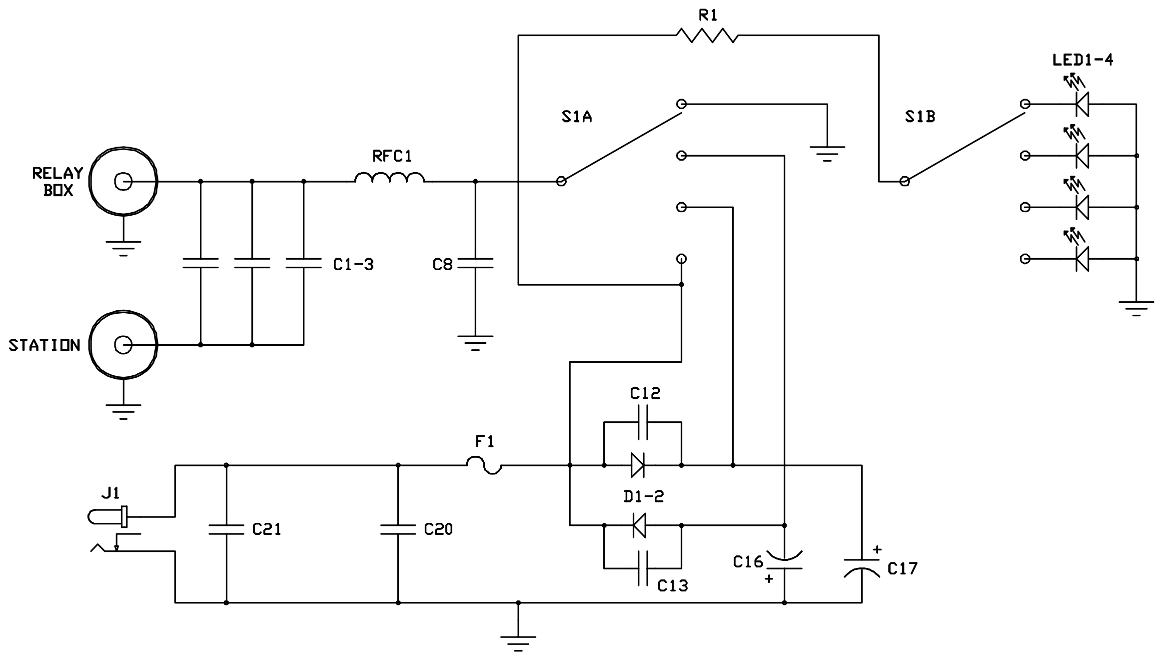
Console Box

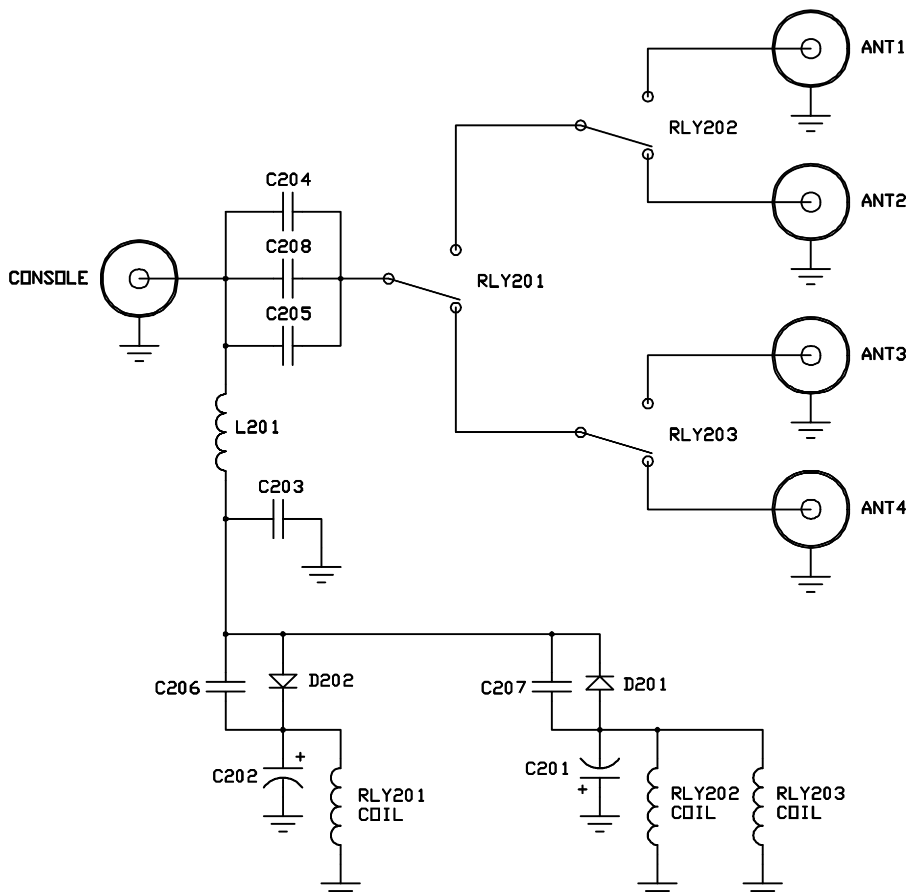
Designator	**Part Description**	**Part Number**
R1	470 ½ watt	101-2470
C1,2,3,8,20	.01 uF 1KV	200-2100-2
C12,13,21	.01 uF 100V	200-2100-1
C16,17	220 uF 25V	270-6220-1
D1,2	1N4007	300-4007
LED1,2,3,4	1.5V Red	351-3002
Power Adapter	120VAC	407-1072
Power Adapter	240VAC	407-1072X
RFC1	Choke	409-2150
S1	Rotary Switch	500-0563
S2	Toggle Switch	503-1233
F1	1 AMP 125VAC FB	755-0101

Relay Box

Designator	**Part Description**	**Part Number**
C201,202	220 uF 25V	270-6220-1
C203,206,207	.1 uF 100V	200-3100
C204,205,208	.01 uF 1KV	200-2100-2
D201,202	1N4007	300-4007
L201	Choke	409-2150
RLY1,2,3	Relay	408-6114

SCHEMATIC


R1
LED1-4
S1A
S1B
RELAY BOX
RFC1
C1-3
C8
STATION
C12
F1
J1
D1-2
C21
C20
C16
C17
C13


ANT1
RLY202
ANT2
C204
C208
CONSOLE
RLY201
C205
ANT3
L201
RLY203
ANT4
C203
C206
D202
C207
D201
C202
RLY201 COIL
C201
RLY202 COIL
RLY203 COIL

NOTES

Antenna Measuring Notes:

Kent Britain WA5VJB (Written for Scatterpoint issue 1-2000 updated Sept 2006)

Since 1987 I have set up my portable antenna range at 26 Conferences measuring well over 1500 antennas, mainly in the 0.9 to 24 GHz range. G4DDK has asked me to list some of my observations.

The Feed is not at the focus of the dish:

First off, I have NEVER been able to calculate the focal point of my dish, mount the feed, and have the antenna optimized. NEVER! It always seems I have to move the feed in towards the dish a bit to tweak things up. But out of the antenna range things are far worse. About half of the dishes have the feed off by as much as 50% in distance!

A chap comes up with a 2 ft. dish and about a 0.35 f/d. The feed is sticking out 3 ft from dish! "But that's where I calculated the focus to be!" is always the answer. I haven't found out what in the $D^2/16c$ equation throws them, but we see it all the time. Another problem is the rounded edge on most dishes. They measure the physical diameter of the dish, not the diameter of the actual parabolic surface. That outer cm or so of many dishes is not usable and should not be used in the F/d calculations. And I won’t even start on the complications of calculating the actual phase center of the feed.

I have always been able to pick up a dB or two tweaking the focus and 6 dB or so has been the typical improvement at the conferences when the feed is movable and we can optimize its position. And finally come the 25% or so really bad ones. The "dish" was not parabolic, the feed wasn't resonate in the ham band, the focus was miscalculated by 3 feet (on a 2 ft dish!), using a grid dish on 3cm (and 3cm spacing on the wires), and so on. As I said, typically 25% or so of the dish antennas tested at these conferences are just air cooled dummy loads.

Most of these really bad ones are usually the prime focus dishes. With the offset dishes, you usually have a pretty good idea where the feed was for a starting point if you had saved all the parts. But the ham feeds will usually have a different phase center, so we're back to seeing several dB of improvement moving the feed around a few millimeters.

The antenna range is also a good spot to figure out where the antenna is pointing. Build up some kind of mechanical sight, or mount a telescopic sight on the edge of the offset dish. (Top edge works well too) Peak up the signal, and sight in on the source. An optical sight can be very useful when portable.

On Yagi and Quad loop type antenna, the builder has often used a different diameter boom, or different size elements, or even replaced a round boom with a square boom. In each case there was no attempt to use corrections factors. (50/50 chance they would have gone in the wrong direction anyway!) Again a large percentage of these antennas are not close to what the owners are expecting in the way of performance.

If you tested all the microwave antennas in England, I am sure very few of the antennas would have the dB’s you have been optimistically using in your range calculations. Interestingly both the UK and ZL groups left the Microwave Update antenna range saying, “This antenna measuring is not all that hard” and are both looking at setting up antenna ranges back home.

Now we will explain how it is not necessarily complicated to set up an antenna range.

Equipment:

- RF Source
- Source Antenna
- Reference Antenna
- Detector
- Open Space

RF Source 1000Hz vs. CW:

Many of my first antenna range set-ups as just a CW source, a reference horn, and a power meter. Hold up the power sensor and horn, measure power, attach the antenna to be measured, and the difference in dB power is the difference in dB gain.

This works, but you really have some dynamic range problems. The power sensor is not very sensitive, so you have to run a fair amount of power and use a short range. But it does work. Just make sure you have at lease 10 dB more power that the noise floor of the power meter, otherwise you run into (Signal + Noise) / Noise problems. I have been able to make pretty good measurements with 10 to 30 milliwatts sources into 20 dB gain antennas on 6 cm and 3 cm. Horns were measured at about 5 Meters, dish antennas at about 10 Meters from the source.

Generating 1000 Hz:

I have a Wavetek 3001 500 MHz synthesized signal generator I haul to the antenna range. Most RF generators already have a 1000 Hz AM setting. So up to 500 MHz I just set the generator to max output, 1000 Hz AM and drive a source antenna with it.

On 902 MHz, I set the generator to 451 MHz and drive two sides of a mixer, this doubles to 902 MHz which goes through a filter and into a 20 dB gain amp. This gives me about 100 milliwatts to work with.

On 1296 MHz I set the generator to 432 MHz, horribly overdrive a small brick amp, filter the 3rd harmonic, and drive a second brick amp. Again, about 100 milliwatts to work with.

On 2304 MHz, I set the generator to 384 MHz, again horribly overdrive a small brick amp, filter the 6th harmonic, and drive a second brick amp. This gives me about 75 milliwatts to work with, and there is a second similar unit for 2400 MHz.

For 3456 MHz I again use a brick amp (Hand picked this one) driven with 432 MHz and run the 8th harmonic through an interdigital filter. A second brick amp brings this up to 10 milliwatts or so.

On 5.7 GHz, 10.3 GHz, and 24.1, GHz I use Gunn sources driving PIN Diodes.

Sometimes I use a 555 timer circuit AA5C built up for me, other times I just drag along a function generator and directly drive the PIN Diodes. On 47 GHz I have a 23.5 GHz Gunn source driving a doubler out of an old HP 940A. I modulate a PIN diode on the 23.5 GHz source. So a lot of ways to generate a 1000 Hz modulated RF source. Of course if I had a Signal Generator actually on these frequencies, or even a sweeper with an external modulation input, I would use it. On 80 GHz, my Gunn source has a modulator built into its commercial power supply.

Source Antenna

You will need an antenna at the source end. It's nice if the antenna has a fair amount of gain and over the years I have used everything from Coffee Can horns, to 2 ft dish antennas on 3 cm. Over the years I have migrated to multiband antennas at the source, just to speed set-up and less stuff to haul about. Ridged horns work well, some the multiband dish feeds work well too. While it is nice for the source antenna to have gain, it is not necessary and I am a firm believer is using what works. More on the type of antenna to use under Open Area.

Detectors/terminations

At the receiver end we need a simple diode detector to demodulate the 1000Hz AM signal. I normally use a standard Type N Input diode detector. Now, most of these detectors in the US do not contain any kind of terminations. So they don't look like a 50 load, but rather have very complex input impedance. Just put a 6 dB pad on the input of the detector. 10 dB works better, 20 dB has too much loss, and the input is pretty much 50? For the higher bands, the simple diode detector mounted in WG works well.

Receiver:

If you are using CW and a Power Meter, then this is your receiver. If you are using 1000 Hz, then you need an HP-415, HP416, or the Marconi Type 6593A. Many other companies also make these 1000 Hz "SWR Indicators". These are simply an audio meter tuned to 1000 Hz with a high accuracy meter scale. I have also used General Microwave and NARDA versions of the HP415 and they work just as well.

Note: The HP415E needs 9 Volts to run, 16 volts to run in the expanded scale mode. It only pulls about 5 ma, so I will wire in two 9 volt dry cell batteries and can run it for hours and hours on the antenna range.

Reference Antenna:

The most important part of the antenna range is an antenna you know the gain of The hand of God, or someone with a crayon, has written the gain of the antenna on a calibration sticker, or Post-it-Note. We measure how much signal the Reference antenna collected, and if the antenna being tested collects 3.2 dB more signal, then it has 3.2 dB more gain than the Reference. On all bands above 900 MHz, I use horn antennas as the reference. In several cases I was fortunate to acquire Std. Gain Horns, and the gain of a horn antenna can be easily calculated with high accuracy.

But like any ham activity, absolute gain numbers are not as important as optimizing the antenna. We will spend hours tweaking the output of a power amp, or the NF of a Pre-amp, and we know the equipment is not calibrated for the frequency we are using. But Max Power Out is still Max Power Out weather it is 68 Milliwatts, or 92 Milliwatts, it's all we can squeeze out of that circuit. Same for the antennas.

You move the feed around, try several feeds, and so on, even if the range errors are a dB or 2, we have maximized the performance of the antenna and been able to compare the relative performance of different antennas.

Again if the real gain of the antenna is 29.6 dBi or 30.4 dBi is all academic, we have squeezed everything we can out of the antenna. (Or thrown it in the rubbish bin!)

Audio out:

The solid state HP-415's have a "Recorder Out" connector on the back. I usually connect a small audio amp with a speaker to this connector. The raw 1000 Hz can be amplified to drive a speaker.

Several good reasons to listen to the audio signal. It's nice to peak the antenna on a audio signal, especially when you're holding the dish with one hand, moving the feed with another hand, and holding the detector with the third hand .... you know what I mean.

And it is especially good when there might be interference. Some time back I was testing an L-Band Helix for possible use on Phase 3-D. The meter was jumping all over the scale; there were several peaks away from the source, and a constant erratic noise floor on the meter. After some time I connected the audio amp and figured out the problem in nano seconds. Loud video buzz! The long helix was acting like a 1/4 wave whip on TV Channel 4! All further testing included either a 1269 MHz filter or an isolator. I have had similar problems testing Log Periodics that do not have the back ends of the booms terminated. At our Central States VHF Conference we typically have the 50-450 MHz and the 900+ MHz ranges running at the same time. Listening to the tones lets us easily tell when that 1296 MHz rhombic also working as a144 MHz antenna.
(Our 1000 Hz tones are hardly phased locked)

Open Area:

30 to 40 Meters is nice, but I have often set up in more confined areas of 10 to 20 Meters. But I try to avoid areas near walls that might cause reflections. Given a choice, I set up on grass (easier on my feet) but parking lots can also be used.

The whole idea is to find an area where you have a consistent signal about the same size as the capture area of the antenna. i.e. a bit bigger than the biggest antenna you plan to test. Our greatest source of error is having the signal level on one edge of the dish stronger than on the other edge of the dish.

Some of the English lads were looking at me pretty funny while I was waving a horn antenna all over the parking lot at uWave Update. (The US guys had seen me do this before.) Up, Down, Left, Right, and Back up a bit. The antenna range is not pre-planned geometry; I am just looking for an area about 1 meter by 1 meter where the signal level varies less than 1 dB. When I find it, I put some kind of marker on the ground, and then tell everyone how high to hold their antennas.

I gave up on elevated ranges a few years ago. I almost always set up with the source antenna (Usually a horn) sitting right on the ground. Thus the antenna and its reflected image are virtually the same point. Sometimes the horn is sitting on a sheet of metal, sometimes it's sitting on a sheet of absorber. Sheets of the Carbon loaded foam work well if you don't have an Eccosorb. Also the sheet of magnetic material that hold advertising to your fridge work well as Iron loaded absorber. The sheet metal gives me a little more signal; the absorber usually gives me a cleaner test area. Although there is no hard fast rule here, I just use what ever works best. If there is a nice consistent signal area, we start measuring antennas!

Measurement technique:

Substitution: Measuring itself is simple and quick. Hold up the reference antenna, set the meter to a convenient spot, attach the sensor to the antenna to be tested, hold it at the same spot, take a reading, and calculate the difference. I normally carry some kind of marking pen and write the results on the antenna. We usually have someone else standing around with pen and paper making a more complete record, but the guys seem to like having an "Official Result" right on the antenna rather than trying to remembering it, or waiting a month until someone publishes the results.

Dynamic Range: One pitfall is the dynamic range of the SWR Indicator or power meter. You like to keep less than 10 dB difference between the antennas under test. So don't use a dipole as the reference for a 30 dB gain antenna measurement. First of all the meters have errors the farther you stretch them. Second the capture areas of the two antennas will be quite different.

A large number of secondary problems arise when testing antenna with vastly different capture areas. With the 415's or 6593's you want to keep them down in the 30, 40 or 50 dB ranges. Higher than 30 usually means the diode is driven out of the square law region, in the 60's the signal will be pretty noisy. These meters will also work with bolometer mounts. Now you could use all the scales with a bolo, but the bolo is less sensitive than a diode mount and you will need more signal.

The 6593 can be used to directly compare 2 antennas, but this means you will need to find a larger measurement area, bigger than both antennas, to make your measurements. This is easy enough on 50 MHz - 432 MHz, but much more difficult on the microwave bands. I haven't used a 6593, but going over one in G4DDK's garage, it sure looked like a natural for antenna ranges.

Results:

Oh it was fun in the early years deflating egos. "Well, a 5 element Yagi would have 12 dB gain, using quad elements adds 2 dB, and a corner reflector would have 10 dB, so by combing a Yagi, Quad, and corner reflector, my super antenna has 24 dB GAIN!" Yea, sure, here's the detector. (6 dBi if he was lucky!).

Over the years the wild claims have died down, and better, more consistent designs are showing up. And we have developed a bit of a tradition of seeing what kind of strange antennas we can show up with and still get good results. And a sprit of experimentation has developed where guys are not afraid to show up with a dish, 8 feeds, and find out which one works best. Typically at the CSVHFS antenna contests we will measure 100 to 125 different combinations of antennas.

There have been a few fun ones; I particularly remember KB0HH spending several years trying to optimise a scalar feed. With excellent form, his cowboy boot set the feed over 30 meters down the range!

Circular Polarization:

We usually get a few CP antennas to test. Normally I just measure the gain, rotate the antenna 90 degrees, measure the gain, average the numbers add 3 dB, and label the gain dBiC.

Ideally, the gain does not change as the test antenna is rotated. If gain only varies 1 dB I'll congratulate the builder, if it varies 3 dB I'll still call it CP, more than 3 dB and we'll start looking at ways to fix/repair/improve the antenna. This is especially a problem with some of the "Short" Helix dish feeds that have become popular lately. It is very difficult to properly generate a CP wave in only 2 turns of wire.

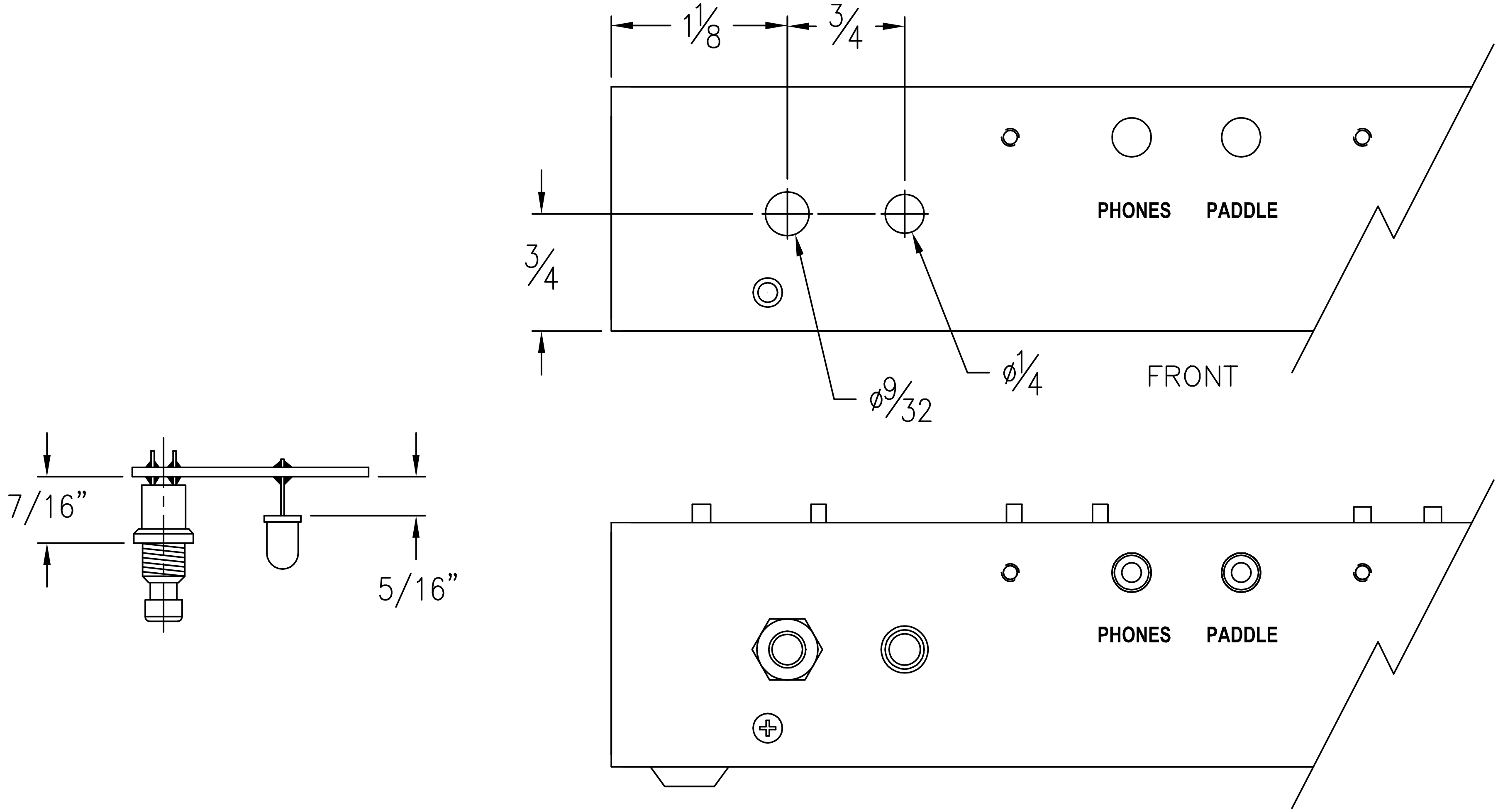
At an AMSAT Conference we set up the antenna range and only 4 of the 8 Helix antennas had gain along the axis of the antenna! Of the 4 with gain, only 2 were within 3 dB of circularity. And yes, 1 of the 2 had been brought by James Miller G3RUH.

The AMSAT lads have been passing around the idea that Helix antennas are easy to build and fool proof. Test of dozens of Helix antennas says they are WRONG. AMSAT writers perhaps have the worse habit of coping articles. A guy writes an article about a Helix, that is copied from and article, that was copied from and article....... And over the last 5 generations of this design, each writer/builder has substituted materials, slightly changed dimensions, and NEVER tested the antenna.
(Pitfalls in Helix antenna design is another paper I have somewhere.)

Log Periodics:

LP's can also be difficult to test, especially the ones that do not terminate the back of the booms. The antenna picks up fundamental and harmonic frequencies equally well. They also tend to pick up more local interference. A clean source and monitoring the 1000 Hz audio will usually keep you out of trouble. The unterminated LP's tend to act like a big capacitor and pick up noise from the mains and a lot of other garbage. All my current LP designs terminate the back of the booms; it just cleans up so many problems.

Battery Status Indicator board mechanical installation for the PFR-3



1 – Solder the switch and LED to the dimensions shown away from the surface of the BSI board.
2 – Remove your main pcb from the upper chassis half and carefully drill the two holes as shown above.
3 – Install the LED clip from the outside, and place your completed BSI board, on the inside, in your two drilled holes.
4 – Re-install the main pcb, install the push button switch nut, and lock the LED into the clip.
5 – Connect two wires from the BSI board to the battery holder terminals, observing polarity.
6 – Re-assemble the two chassis halves.

Tactical Communications Procedures

In the past, military units used drum signals and bugle calls to communicate orders on the battlefield. Colonial Militia and Light Infantry units often used whistle commands for the same purpose and such signals can still be used today to coordinate small unit actions like raids and ambushes. Military communications may take the form of visual signals, sound signals, radio messages, telephone conversations or written messages delivered by courier. Since two-way radios are the primary means of modern tactical military communications, this information paper primarily concerns radios, but many procedures apply equally to field telephones used in semi-permanent or defensive positions.

Basic Overview of Radio Types. U.S. Military forces use small handheld radios (like the AN/PRC-126) or backpack radios (like the AN/PRC-77 or AN/PRC-119) with low power and limited range down to the squad and even fire team level, while higher echelons with a need to communicate with more units over greater distances use more sophisticated and powerful radios. Older tactical military radios operated in the VHF FM frequency range of 30.00 to 75.95 megahertz (MHz), while newer radios extend the range up to 87.975 MHz giving 2320 channels. While not approved by higher headquarters, it is not uncommon for U.S. military troops to use privately purchased hands-free voice-activated (VOX) radios, like the Maxon 49 MHz Tracker radios (about $40 to $70) with a 1/4-mile range, for coordination of operations at the platoon level and lower. Such short range VOX transceivers are in wide use by police SWAT teams and would also be useful for Militia tactical operations. Handheld or mobile Citizens Band radios (about $40 to $150) operating in the 26.965 to 27.405 MHz frequency range can also be used for short range tactical communications, but their use should probably be restricted to training and administrative control functions, like vehicle convoys or firing range operations. Under certain conditions, background noise on the AM Citizens Band can make it virtually impossible to communicate even a half-mile away. A better choice for Militia use than a standard CB would be a Single-Sideband (SSB) transceiver (about $170), which gives all the functions of a CB and can also transmit in Upper Sideband (USB) and Lower Sideband (LSB) modes. A standard CB radio transmits a signal when the mike is keyed, which wastes power and reduces its range. In SSB transmission modes, almost no signal is sent until the operator starts talking, giving an effective power of about three times an ordinary CB. With a 102" stainless steel whip antenna an SSB radio has a range of about 30 to 35 miles under all but the noisiest conditions. Single-Sideband radios can usually be fine-tuned in 1-kilocycle increments between each channel, which effectively gives a capability of 400 channels instead of 40 and three transmission modes (CB, USB and LSB). Outlaw CB operators frequently make use of a wider frequency range than allowed by the FCC by transmitting above or below the allowed CB frequencies using illegally modified or imported radios. They also illegally increase output power by using linear amplifiers of 1000 watts or more (although 100 to 300 watts is the norm). Without a proper antenna a linear amplifier can destroy a CB radio. Since out-of-band and excessive power violations of the FCC rules can result in substantial fines and even imprisonment, such illegal setups are not recommended and can only be justified by a genuine survival emergency. If you need more range and power than CB, get an FCC Amateur Radio license, which will open a wide array of other communications options. If you don't want to learn Morse code, you can take

two written exams on FCC rules, basic electronics and radio theory (study materials are available at Radio Shack) and get a no-code Technician license. With a 5-word-per-minute Morse code exam you can upgrade to Technician-Plus class and will be allowed to transmit continuous wave (CW) Morse code, which can get messages through conditions that prevent voice communications. Either Technician class license will allow you to use probably the best type of radio for Militia tactical communications; the VHF FM 2-meter band (144 to 148 MHz frequency range). There is a wide network of repeaters in the 2-meter band that will allow you to extend the range of your radio communications by rebroadcasting your signal on a different frequency at a higher power, usually from a high terrain location. Some repeaters will also allow autopatch connections to the commercial telephone system. Many 2-meter band radios feature the continuous tone-coded squelch system (CTCSS) which lets you program your radio to ignore all calls that don't send a particular sub-audible tone you select. Many 2-meter band radios can also use dual-tone multi-frequency (DTMF) tones to selectively make calls to a particular station or different groups of stations. Radio communications on the same frequency where only one station can transmit at a time (like CB) are called simplex. Communications where both stations can transmit at the same time (like a telephone) are called duplex. Most 2-meter band radios are capable of duplex operation by transmitting and receiving on different frequencies and some can be programmed to automatically jump periodically between different frequencies, which makes unwanted monitoring more difficult. The 2-meter band can make use of packet signals using digitized voice or digital communications between computers. Such digital communications can provide the highest degree of privacy and security for your messages; more about this in the section on codes. Handheld 2-meter radios can often be fitted with either a separate microphone or VOX headset for belt or backpack mounting and can be used with an amplifier and better antenna, giving increased range for base or vehicle use. Radio Shack sells a 2-meter band handheld for $260 (plus $120 for a 30-watt amplifier and $40 for a vehicle type antenna) and a 45-watt mobile transceiver for $350. A test of an ICOM 25-watt 2-meter band radio by "American Survival Guide" using a simple mobile antenna from a 19th floor apartment reported reliable communications in the 40 to 50 mile range, but stated that results will vary with terrain and antenna quality. 2-meter band radios can usually receive a wide range of VHF signals (allowing you to monitor police and other emergency broadcasts) and may be capable of transmitting above or below the authorized band in an emergency endangering life or property. Regular use of the military VHF frequencies outside the 2-meter band requires licensing by the appropriate military agency concerned with the Military Affiliate Radio System or the Civil Air Patrol. Whether you choose CB, Single-Sideband or 2-meter VHF FM for your Militia tactical communications, for field use it would be useful to have a mobile vehicle type transceiver rigged to a backpack mount with a rechargeable battery pack and with both a short range walkie-talkie type antenna and a longer range whip antenna.

Radio Equipment Use. Factors that affect the range of radios are weather, terrain, power, antenna, and the location of the radio. Manmade objects such as buildings and bridges may adversely affect radio transmission. Interference may also come from power lines, electrical generators, bad weather, other radio stations, or enemy jamming. You can correct many of the causes of poor radio communications by using common sense. For example, make sure you are not trying to communicate from under a steel bridge. However, some precautions you must take when using radios are not intuitive. For efficient operation and to prevent equipment damage you should avoid contact with an antenna while transmitting, you should never transmit without an antenna being connected, radio sets should be turned off prior to

starting a vehicle, whip antennas must be maintained in a vertical position during use and must be stowed so they don't contact power lines during transport. Equipment maintenance precautions include insuring plugs and jacks are clean, antenna and power connections are tight and batteries are fresh.

Rules for Radio Use.

* Listen before transmitting and release the push-to-talk button immediately after speaking.
* Make messages clear and concise. Know what you are going to say and, if possible, write messages out before transmitting.
* Speak clearly, slowly, and in natural phrases, distinctly enunciating each word. If the receiving operator must transcribe, allow time for writing.
* Always assume the enemy is listening.

Procedure Words. Standard procedure words (prowords) are used in military communications to keep transmissions as short and clear as possible. For instance, you say WILCO instead of YOU GOT IT DUDE and you never say ROGER WILCO OVER AND OUT when you should say WILCO OUT. Some prowords have different meanings depending upon which band of the radio spectrum you are using. BREAK on the Citizens Band means you want to transmit on a particular channel (e.g. BREAK 35), while on the licensed amateur radio bands it means an emergency transmission which takes priority over routine traffic (e.g. BREAK - EMERGENCY - BREAK). The proword BREAK on military networks means separation of the message text from other parts of a message. The definitions of prowords commonly used in military communications are printed at the end of this paper.

Pronunciation of Letters and Numerals. To prevent misunderstanding by the receiving station, spell difficult words using the phonetic alphabet (printed at the back of this paper). For example: PIDCOKE, I SPELL - PAPA INDIA DELTA CHARLIE OSCAR KILO ECHO - PIDCOKE. In military communications, the phonetic alphabet is also used to transmit five-letter code groups in encrypted messages. Numbers in radio messages, such as times, grid coordinates and call signs, are spoken digit by digit and are pronounced as shown at the back of this paper.

Communications Security. Radio communications are always subject to intercept by enemy forces, so security rules and discipline are strictly enforced on each military radio network by a Net Control Station (NCS; usually the highest headquarters on the net). Since operational requirements may limit the security measures that can be used, rules governing communications security do not guarantee security in every conceivable situation. However, a satisfactory degree of security can be obtained by sensible application of security rules. Whenever possible electronic scrambler or encryption units are used. Even if the rest of a transmission is made in clear language, critical numbers like times, unit status and grid coordinates are manually encrypted and sent using an authorized code. In addition to encryption, prevention of enemy intercept, traffic analysis and direction location is achieved by brevity of transmissions, avoiding excessive radio checks, operating radios on low power with directional antennas, placing intervening terrain between the transmitter and enemy positions whenever possible, and restricting transmissions to certain prearranged times except for dire emergencies. When unknown stations attempt to enter a radio

net, they are challenged with an authentication procedure. Call signs are used in place of plain language unit names. Call signs and frequencies are periodically changed to alternates at prearranged intervals or when directed by the NCS. During the war in Vietnam, many U.S. military units adopted a procedure of using the same one or two word call sign for every station on a radio net and ending each call sign with a number or letter indicating the unit (e.g. 3 for the Third Platoon or D for Delta Company). The suffix 6 usually indicated the Commander's radio operator and 6-ACTUAL meant the Commander himself was speaking. Such lazy procedures gave away too much information to the enemy. A better call sign system identifies each station with a letter, two numbers and a letter, all chosen at random so that enemy analysis of radio traffic will reveal less information. The FCC does not require call signs on the Citizens Band, but it encourages the use of an operator or organization name or the prefix K followed by the operator's initials and residence zip code. Licensed amateur radio operators are encouraged to frequently use their FCC assigned call sign to identify their transmissions and are required to properly identify themselves at least every ten minutes.

Coded Messages. Military radio communications are often conducted using encryption equipment to automatically scramble every transmission. Critical parts of messages sent over tactical radios without encryption equipment are manually encrypted using code tables to deny information to the enemy. The FCC prohibits the use of codes and ciphers to hide the meaning of a message over both the CB and ham radio airwaves; only plain language transmissions are allowed. However, digital packet radio on the ham 2-meter band allows high speed file transfer between computers. A computer file could consist of a digitized voice message or a written message which has been encrypted by a virtually unbreakable computer program. A field transmission between two laptop computers using mobile 2-meter ham radios would be the equivalent of a highly secure military radio encrypted burst transmission. It would be difficult for the FCC to prove such a clandestine communication was not simply an ordinary computer program or data file.

Training Sample Code System. Operational codes and authentication tables for use during a crisis resulting in calling out the Militia will be developed by your Militia unit's S-2 Intelligence and Security section and will be distributed by the Communications Officer on a need to know basis only. For training purposes only, two copies of a sample code matrix table and a sample authentication table have been included at the end of this paper. One copy has been filled in as an example and the blank copy is suitable for training use; make extra photo-copies of the blank sample page or have it laminated for use with a grease pencil or water soluble marking pen. The top of the page has a sample code matrix table system with the alphabet and words commonly used in military messages; the bottom of the page has a sample authentication table. As with any Militia training, take care to obey all applicable laws. Remember that transmitting codes over the airwaves is a violation of FCC rules and can result in substantial criminal penalties. There are better uses for your money than paying federal fines and it is hard to fulfill your Militia duty from behind bars. Training practice sending coded messages with low power toy walkie talkies with a 25 to 50 foot range would be a virtually undetectable technical violation or you could use Dixie cup and kite string field phones which haven't yet come under FCC jurisdiction.

Using the Sample Cryptographic Key. Actual military codes and authentication tables are changed daily or whenever there is reason to believe they have been compromised. The sample code and authentication

table system is designed to be easily changed based upon a twelve character cryptographic key. The example page has been filled out using the cryptographic key BLACKHORSE7K. The first ten letters of the key, BLACKHORSE, have been written in the blocks across the top of the authentication table. Any word or phrase with ten letters that do not repeat can be used, such as PATHFINDER or DONKEY FISH. You can use words with repeating letters by simply discarding the letters which repeat or exceed ten letters. For instance the phrase CLINTON SUCKS gives a ten-letter keyword of CLINTOSUCK. The number 7 found in the 11th position of the cryptographic key has been written at the top of the left column of the authentication table and the blocks below have been filled-in with the next higher number; when the number nine was reached, the next block was filled-in with zero. The letter K found in the 12th position of the cryptographic key has been written in the lower left block of the code matrix table; the rest of the alphabet was then written in the blocks above and across the top of the code matrix, starting over at A when Z was reached.

Using the Sample Code Matrix Table. To use the sample code system to encrypt a message, find the letter or word you need in one of the blocks and look to the left to find the letter for the row; then look for the letter at the top of the column. For example, the letter Q is encrypted as UZ and the word PLATOON is encrypted as SA. When two or more letters or words are found on the same row, do not repeat the left column letter. For example, the phrase BLACK HELICOPTER is encrypted as VXHWYGMB. When transmitting an encrypted message, send it as five letter code groups (filling in the last group with extra punctuation if necessary) preceded by the proword GROUPS and the number of code groups. For example, you say GROUPS ONE ONE PIMXU JMAQD VYDUD AVYDR YUFVW YUXCG RXTXF VWUYA TFZRW TDAPH RFTHG. Spell out the code groups with the phonetic alphabet (e.g. the first code group above is spoken as PAPA INDIA MIKE X-RAY UNIFORM) The above message translates as ENEMY TANK & APC ATTACK CHURCH LOCATION WACO TX DATE 19 APR 93 REPORT 74 CIVILIAN KIA. The sample code matrix would be harder for an enemy to break if the alphabet were spread over more rows and if the row and column letters were not sequential (naturally, this would require a much longer cryptographic key).

Using the Sample Authentication Table. The authentication table at the bottom of the sample page is used to challenge other stations to prove their identity. The authentication procedure is used by a Net Control Station when other stations request permission to enter its radio net. When an unknown or suspected station attempts to communicate with any station, it may be challenged by saying AUTHENTICATE and giving them a two character authentication code. Using the authentication table, pick a random column and row combination and find the letter in the block where they intersect. If the challenge is AUTHENTICATE HOTEL TWO, then the suspected station would properly respond I AUTHENTICATE LIMA. The row of numbers below the keyword on the sample authentication table is designed to be used to provide a degree of security for numbers in tactical messages that are otherwise transmitted unencrypted in plain language. For example, instead of saying RENDEZVOUS AT GRID DELTA FOXTROT 385644, you would say RENDEZVOUS AT GRID DELTA FOXTROT CHARLIE SIERRA HOTEL OSCAR KILO KILO. The ten letter keyword can be given to patrols or individuals to use even if they don't have the entire code matrix and authentication table.

Military Radio Message Formats. Many tactical radio communications take the form of informal

conversations relaying information and orders, although Net Control Stations still have the responsibility for enforcing security procedures and the use of proper prowords and call signs. Some messages follow a set protocol, like calling for and adjusting artillery or airstrikes and the reporting of nuclear, biological and chemical information. Reports on the sighting of enemy forces are often made using the word SALUTE as a memory aid; Size, Activity, Location, Uniform, Time and Equipment. Formal military messages are usually passed over strategic communications systems, but may also be sent over tactical radio nets. Such messages are transmitted in the following format:

(distant station call sign) THIS IS (your call sign)
(message precedence; ROUTINE, PRIORITY, IMMEDIATE or FLASH)
(date-time group; ddttttz month yy. Numbers are individually spoken and the time is given using 24-hour military time. The letter z above represents the time-zone indicator; ZULU for Greenwich Mean Time or LIMA for local time at the sending station.)
FROM (your call sign or the message originator's call sign if you are relaying traffic)
TO (message addressee call sign; not necessarily the call sign of the distant station you are talking to, since they may have the responsibility for relaying traffic to the addressee)
BREAK (this proword separates the text from the rest of the message)
(message classification; UNCLASSIFIED, CONFIDENTIAL, SECRET or TOP SECRET)
(message text)
BREAK
OVER

To send a priority message (which would take precedence over routine traffic on the net) you contact the distant station and state the precedence of the message you wish to send. For example, if you have a message for S20A, your call sign is Z94D and you are calling D81D (either the NCS or another station in your net responsible for relaying traffic to S20A) you would say:

DELTA AIT WUN DELTA - THIS IS ZULU NINER FOWER DELTA - PRIORITY OVER.

The distant station would respond:

ZULU NINER FOWER DELTA - THIS IS DELTA AIT WUN DELTA - OVER.

You would then send your message like this sample:

DELTA AIT WUN DELTA - THIS IS ZULU NINER FOWER DELTA.
PRIORITY
TIME ZERO SEVEN TOO WUN TREE FIFE ZULU JULY NINER SIX.
FROM ZULU NINER FOWER DELTA.
TO SIERRA TOO ZERO ALPHA.
BREAK
UNCLASSIFIED.

ENEMY AMBUSH LOCATION RUBY RIDGE IDAHO DATE TOO WUN AUGUST NINER TOO REPORT WUN ENEMY KILO INDIA ALPHA WUN FRIENDLY CIVILIAN KILO INDIA ALPHA. ENEMY SNIPER ATTACK SAME LOCATION DATE TOO TOO AUGUST NINER TOO REPORT ONE FRIENDLY CIVILIAN KILO INDIA ALPHA TOO FRIENDLY CIVILIANS WHISKEY INDIA ALPHA.
BREAK
OVER

The distant station would then give you a receipt for your message by saying:

ZULU NINER FOWER DELTA - THIS IS DELTA AIT WUN DELTA. ROGER. OUT.

It is important that every military unit be able to shoot, move and communicate. Learning more about two-way radios and tactical communications procedures will allow you to better serve your community as a well trained and prepared Militia member.

Commonly Used Military Prowords:
ALL AFTER - Part of the message to which I refer is all of that which follows ...
ALL BEFORE - Part of the message to which I refer is all of that which precedes ...
AUTHENTICATE - Station called is to reply to the challenge that follows.
AUTHENTICATION IS - Transmission authentication of this message is.
BREAK - I now separate the text from other parts of the message.
CORRECT - What you have transmitted is correct.
CORRECTION - There is an error in this transmission. Transmission will continue with the last word correctly transmitted.
DISREGARD THIS TRANSMISSION - This transmission is in error; disregard it.
DO NOT ANSWER - Stations called are not to answer with a receipt for this message, or otherwise to transmit in connection with this message. When this proword is used the transmission will end with OUT.
GROUPS - This message contains the number of five-letter code groups indicated by the numeral following.
I READ BACK - The following is my response to your instructions to read back.
I SAY AGAIN - I am repeating transmission or part indicated.
I SPELL - I shall spell the next word phonetically.
I VERIFY - The following message (or portion) has been verified at your request and is repeated. Used only as a reply to VERIFY.
MESSAGE - A message that requires recording is about to be transmitted. Not used on nets primarily used for conveying messages; intended for use on tactical nets.
MORE TO FOLLOW - Transmitting station has additional traffic for the receiving station.
OUT - This is the end of my transmission to you and no answer is required or expected.
OVER - This is the end of my transmission to you and a response is necessary. Go ahead: transmit.
RADIO CHECK - What is my signal strength and readability?
READ BACK - Repeat this transmission to me exactly as received

. RELAY TO - Transmit this message to all addresses or to the address designations immediately following.
ROGER - Have received your last message satisfactorily, loud and clear.
SAY AGAIN - Repeat all of your last transmission. Followed by identification data means "REPEAT (portion indicated)".
SILENCE - Cease transmission on this net immediately. If repeated three or more times, silence will be maintained until lifted.
SILENCE LIFTED - Resume normal transmissions. Silence can only be lifted by the station imposing it or by higher authority. When an authentication system is in force, the transmission imposing and lifting silence is to be authenticated.
SPEAK SLOWER - You are transmitting too fast: slow down.
THIS IS - This transmission is from the station whose designator immediately follows.
TIME - That which immediately follows is the time or date-time group of the message.
UNKNOWN STATION - The identity of the station with whom I am trying to establish communications is unknown.
VERIFY - Verify entire message (or portion indicated) with the originator and retransmit correct version. Used only at the discretion of the addressee of the questioned message.
WAIT - I must pause for a few seconds.
WAIT, OUT - I must pause longer than a few seconds.
WILCO - Have received your last message, understand it, and will comply; to be used only by the addressee of a message. Since the meaning of ROGER is included in that of WILCO, the two prowords are never used together.
WORD AFTER - I refer to the word of the message that follows ...
WORD BEFORE - I refer to the word of the message that precedes ...
WORDS TWICE - Communication is difficult; transmit each phrase or code group twice. Used as an order, request or as information.
WRONG - Your transmission was incorrect. The correct version is ...

Phonetic Alphabet:

A Alpha (al'-fah)
N November (no-vem'-ber)
B Bravo (brah'-voh)
O Oscar (oss'-cah)
C Charlie (char'-lee)
P Papa (pah-pah')
D Delta (dell'-tah)
Q Quebec (keh-beck')
E Echo (eck'-oh)
R Romeo (row'-me-oh)
F Foxtrot (foks'-trot)
S Sierra (see-air'-ah)
G Golf (golf)

T Tango (tang'-go)
H Hotel (hoh-tell')
U Uniform (you'-nee-form)
I India (in'-dee-ah)
V Victor (vic'-tah)
J Juliett (jew'-lee-ett)
W Whiskey (wiss'-key)
K Kilo (key'-loh)
X X-Ray (ecks'-ray)
L Lima (lee'-mah)
Y Yankee (yang'-key)
M Mike (mike)
Z Zulu (zoo'-loo)

Phonetic Numbers:
1 wun
6 six
2 too
7 sev'-en
3 tree
8 ait
4 fow'-er
9 nin'-er
5 fife
0 ze'-ro
44 fow'-er fow'-er
90 nin'-er ze'-ro
136 wun tree six
500 fife ze'-ro ze'-ro
1200 wun too ze'-ro ze'-ro
1478 wun fow'-er sev'-en ait
7000 sev'-en tou'-sand
16000 wun six tou'-sand
812681 ait wun too six ait wun

**[The sample code matrix and authentication systems described in the text of the information paper were printed on two pages; one sample page was filled-in as described in the text and the other was left blank for training use. To reconstruct the code system, at the top of the page make a table with 12 rows and 16 columns. Write the 26 letters of the alphabet, the numerals 0 through 9, some punctuation and words commonly used in military messages in the blocks. You can fill-in the blocks however you choose, but if you don't use the sample below, then the examples in the text will not be correct. Make an extra row above these blocks and an extra column to their left and leave them blank; these will contain your cryptographic key as described in the text. The authentication table at the bottom of the page has ten

rows and ten columns. Fill in the 100 blocks with random letters of the alphabet. Use the example below or correct the text example to match your system. Make an extra row at the top of the table and place the numbers 0 through 9 left to right in these boxes. Make a blank extra row at the top and a blank extra column to the left for the cryptographic key. To the right of the authentication table you should have room for six lines to be filled in by the radio operator. Label these lines Call Sign, Alternate Call Sign, Radio Frequency, Alternate Radio Frequency, Net Control Station Call Sign, and Alternate NCS Call Sign. Make two copies of this page; leave one blank and fill the other in using the cryptographic key BLACKHORSE7K in the manner described in the text.]**

[The blocks in our training sample code matrix were filled-in as follows (separated by the backslash character)]

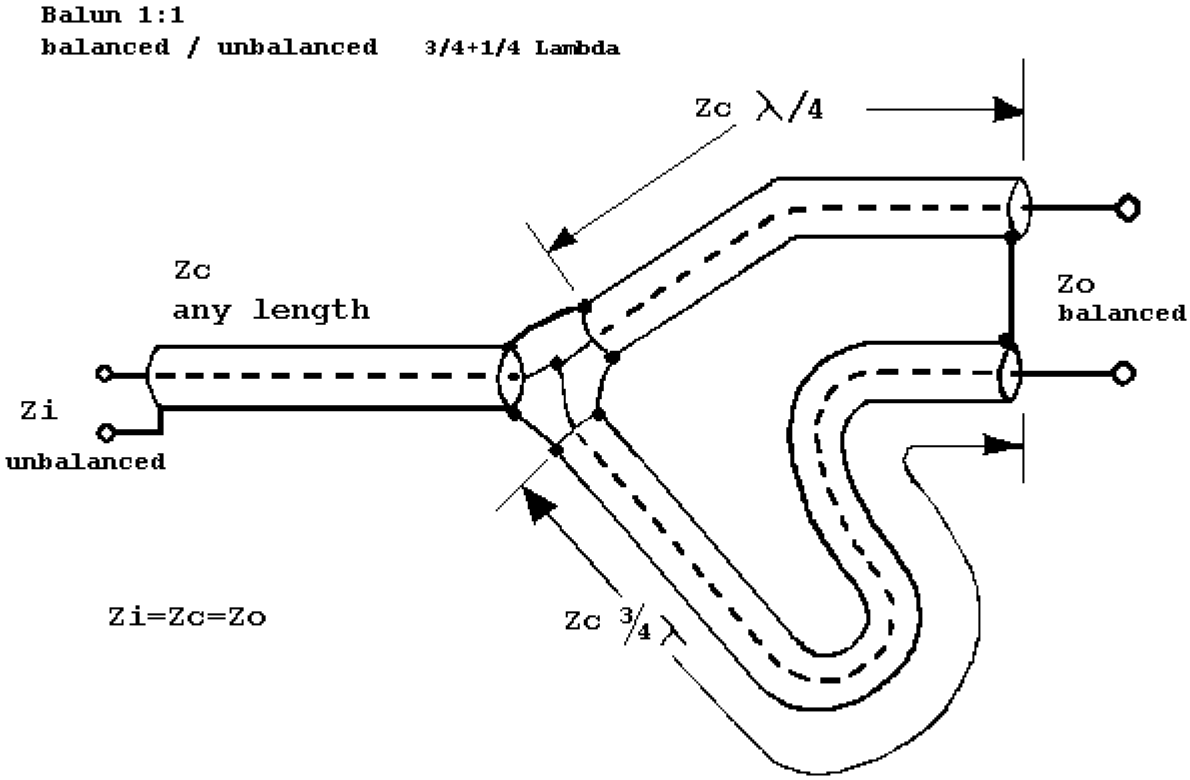
row 1 A \ B \ C \ D \ E \ F \ G \ H \ I \ J \ K \ L \ M \ ?
row 2 N \ O \ P \ Q \ R \ S \ T \ U \ V \ W \ X \ Y \ Z \ &
row 3 0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ 7 \ 8 \ 9 \ + \ # \ odd \ even
row 4 UNIT \ patrol \ team \ squad \ platoon \ company \ battalion \ leader \ commander \ detachment \ attached \ forward observer \ medic \ med-evac
row 5 REPORT \ date time \ coordinate location \ personnel \ weapons \ ammo \ food \ water \ equipment \ KIA dead \ WIA wounded \ MIA missing \ POW captured \ radio frequency
row 6 OPERATIONS \ raid \ recon \ ambush \ move to contact \ assemble \ fortified \ attack \ defend \ patrol base \ link-up \ listening post \ observation post \ meeting
row 7 MISSION \ HQ headquarters \ security \ support \ assault \ junction \ building(s) \ crossing \ road \ trail \ forces \ civilian(s) \ enemy \ friendly
row 8 STATUS \ execute start \ terminate finish \ halt stop \ prepare ready \ move go to \ help urgent \ successful \ failed \ aborted \ detected \ waiting \ yes \ no
row 9 DISPOSITION \ change \ new \ we my \ you your \ they their \ send need \ spot observation \ in-position \ lost \ found \ easy \ difficult \ unknown
row 10 TRANSPORT \ tank \ truck \ wheel \ track APC \ helicopter \ plane \ ground \ air \ water \ foot \ vehicle \ paratroop \ heliborne air assault
row 11 MILITARY TERM \ objective \ rallying point \ release point \ target reference point \ line of departure \ phase line \ command post \ area of operation \ by-pass \ enroute \ dig-in \ contact \ break rest
row 12 MILITARY TERM \ signal \ depart \ return \ occupy occupied \ escape & evade \ watch out \ check check-out \ silent \ delay \ cancel \ immediate \ conduct \ withdraw retreat

[The blocks in our training sample authentication system table were filled-in as follows (separated by the backslash character)]

row 1 J \ B \ O \ Y \ I \ K \ M \ D \ S \ J
row 2 U \ R \ C \ L \ A \ O \ B \ Y \ Q \ D
row 3 W \ C \ X \ E \ G \ H \ W \ N \ D \ Z
row 4 B \ N \ F \ R \ T \ S \ C \ I \ R \ P
row 5 U \ J \ V \ F \ I \ X \ T \ C \ M \ O
row 6 R \ P \ B \ M \ S \ L \ M \ N \ S \ A

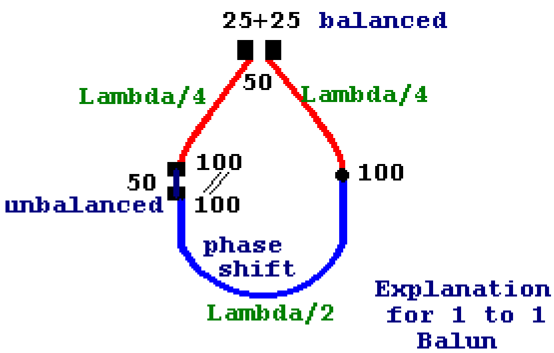
row 7 T \ P \ E \ Q \ A \ I \ O \ E \ P \ X
row 8 F \ J \ Q \ N \ V \ Z \ U \ W \ L \ Q
row 9 Y \ H \ D \ V \ G \ G \ L \ U \ K \ E
row 10 G \ K \ H \ F \ A \ K \ V \ Z \ T \ H

Coaxial Balun by IØQM



Revised from a sketch made by I4BBE in the early 70's

This balun use a ¼ wavelength and the ¾ wavelength adapting sections with the 50-Ohm coaxial cable (Zc), or a coax line with the impedance you need. As the electrical length of both sections include the ¼ wavelength coaxial transformer, and if the unbalanced impedance has the same value of the coaxial cable, then the impedance seen at the other extremes is exactly the same value. For this reasons the name is just 1:1 balun. The length difference between the ¼ wavelength and the ¾ wavelength sections provides for the necessary 180 degrees phase shift as requested from the open dipole radiator. Since the narrow bandwidth, this balun is well suited for the monobander antenna only, and it ideally matches the radiator of the Yagi-Uda VHF/UHF antenna, designed for purely resistive 50 Ohm. Remember to take account of the electrical length of your cable, generally a factor of about 0.659 for most of the cable. So please, use your particular cable specifications. Instead the 1:1 Balun, You can match your 50 Ohm unbalanced Line or with any Zc=Zi unbalanced line to any "balanced" purely resistive Impedance Zo. To do it, replace the ¼ wavelength pair's transformer, with two section of coaxial line at calculated value. This is better explained if you follow the below explanation given as 1:1 balun example.



Coaxial Balun by IØQM

As shown in the 144 MHz balun image, the 1:1 balun is done by the
[¼WL * Vc] coax cable section of Zc impedance; and the

[¾WL * Vc] coax cable section of Zc impedance;
which is three folded to obtain the same physical length of the shortest section, this is not the electrical requirements then it is for practical layout convenience only.

"WL" is the Wave Length ; WL = (constant light speed / frequency)
"Vc" is the Velocity constant of propagation in the coax cable i.e. the electrical length.
"Vc" value is 0.659 for the RG58, please use your particulars "Vc" of your own coax cable.

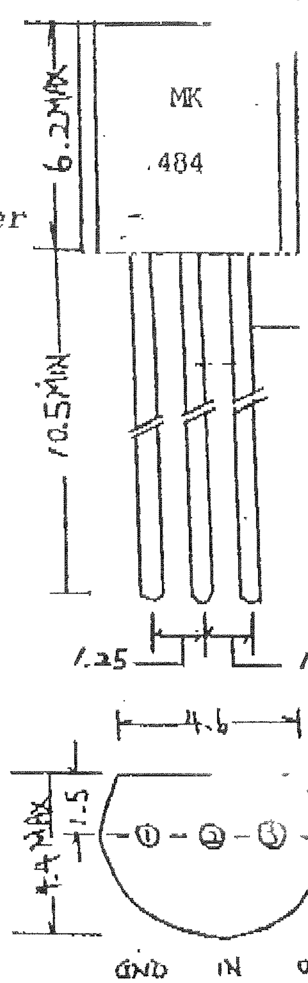
I used RG58 coaxial cable since I use less than 300 W power. Better is the use of the RG142 Coaxial cable with Teflon dielectric, which handle a power of 2 KW (at 144 MHz) with a lower loss also.

You can couple any unbalanced "Zi" to your balanced "Zo" needs, by replacing the two WL/4 pairs transformer "Zc" (red coloured in the balun explanation figure). Even removing them you get the well known 4:1 balun. A very important thing is that you do not need to use any particular "Zc" impedance for the WL/2 section (the blue coloured in the explanation) which is built-in inside the 3/4*wavelength Zc adapting sections, since any WL/2 section do not involve any Z transform. Finally, The mathematical formula for this gear is simply:

Zc = sqrt (Zo * Zi) { **Zc,** is the Impedance value you need in the coaxial balun cable }
Zo = (Zc)^2 / Zi { **Zo,** is the purely resistive balanced antenna impedance }
Zi = (Zc)^2 / Zo { **Zi,** is the final unbalanced value for the Rx / Tx coaxial line }

Practical 1:1 Balun for 144 MHz, ready to use:

igh Sensitivity and high quality AM Radio is possible with a few outside components. As special fetures of the circuit include low supply voltage operation, the device is particulary useful in Watch Radio and lighter with Radio.



FEATURES

1. Stably operates with 1.1v
2. Low Drain Current
3. Small and light weight (TO92)
4. Wide AGC Ranging

APPLICATIONS

Watch Radio
Lighter with Radio
Wireless AM-System

ELECTRICAL CHARACTERISTICS

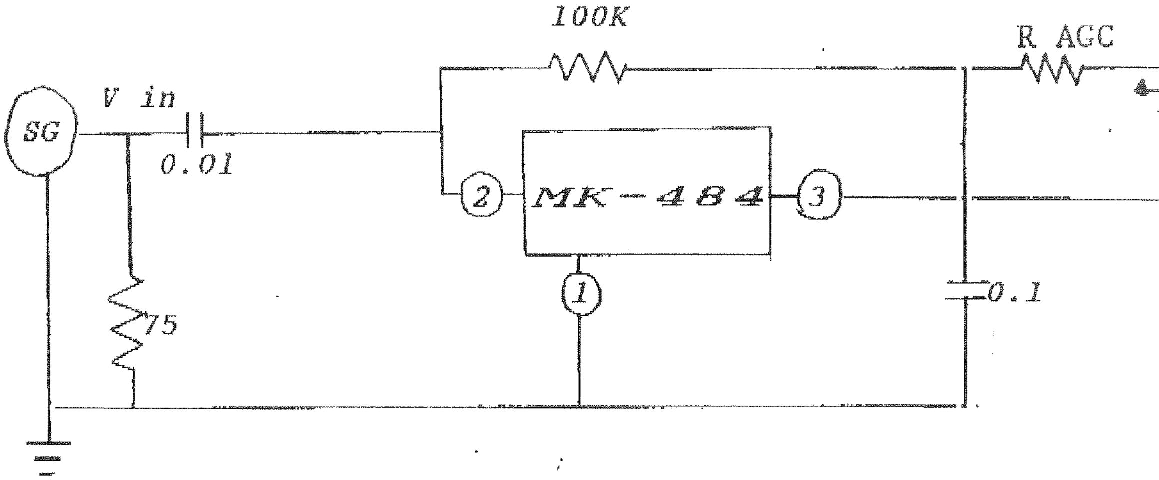
ITEM	SYMBOL	MIN	TYP.	MAX.	UNIT
SUPPLY VOLTAGE	Vcc	1.1	1.4	1.8	V
OUTPUT VOLTAGE (at operation)	VOUT * 1	0.8		1.5	mV
DRAIN CURRENT	Icc		0.3		mA
COVER RANGE	ʃ R	150		3,000	KhZ
INPUT RESISTANCE	Zin		4		MΩ
TOTAL HARMONIC DISTORTION			4		
AGC RANGE	AGC	30			dB
POWER GAIN	Gp		70		dB

Vcc = 1.4V, Ragc = 1.5KΩ, =1,000KHZ
Modelation 1,000HZ 40%, Vin - 1mV (r.m.s.)

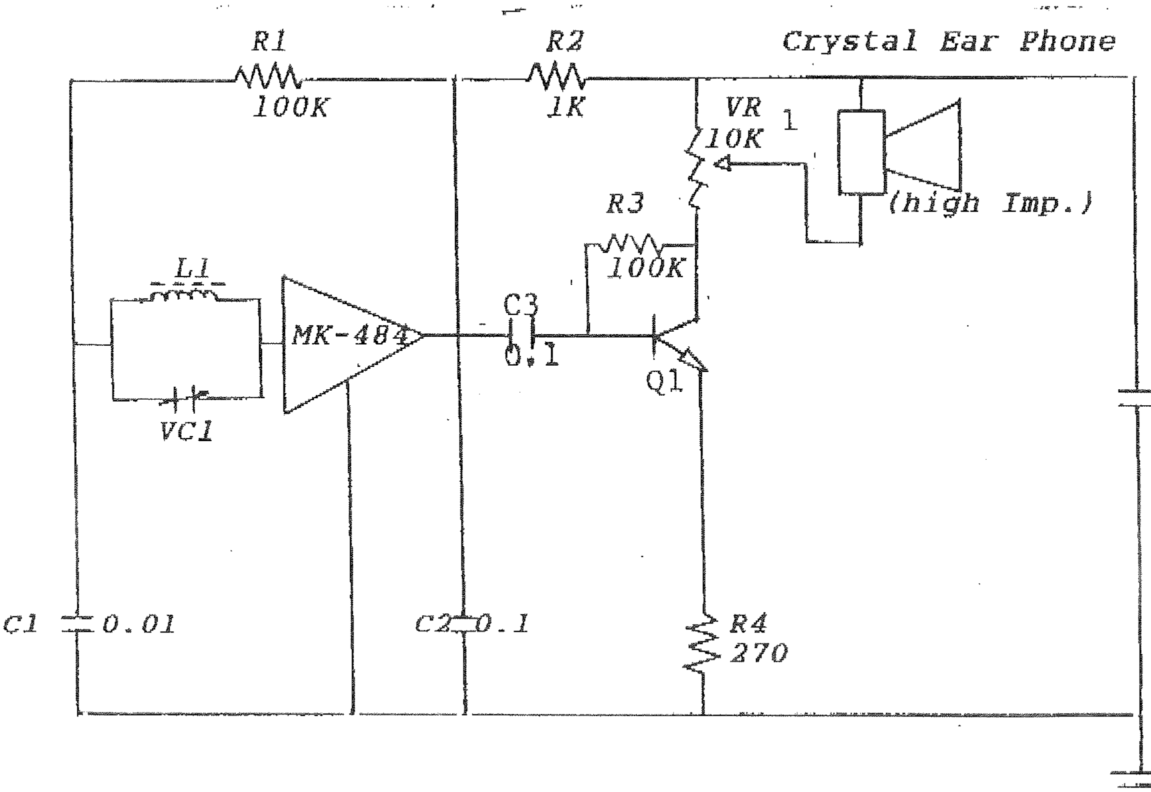
(1) RAGC = 100 - 1.5KΩ

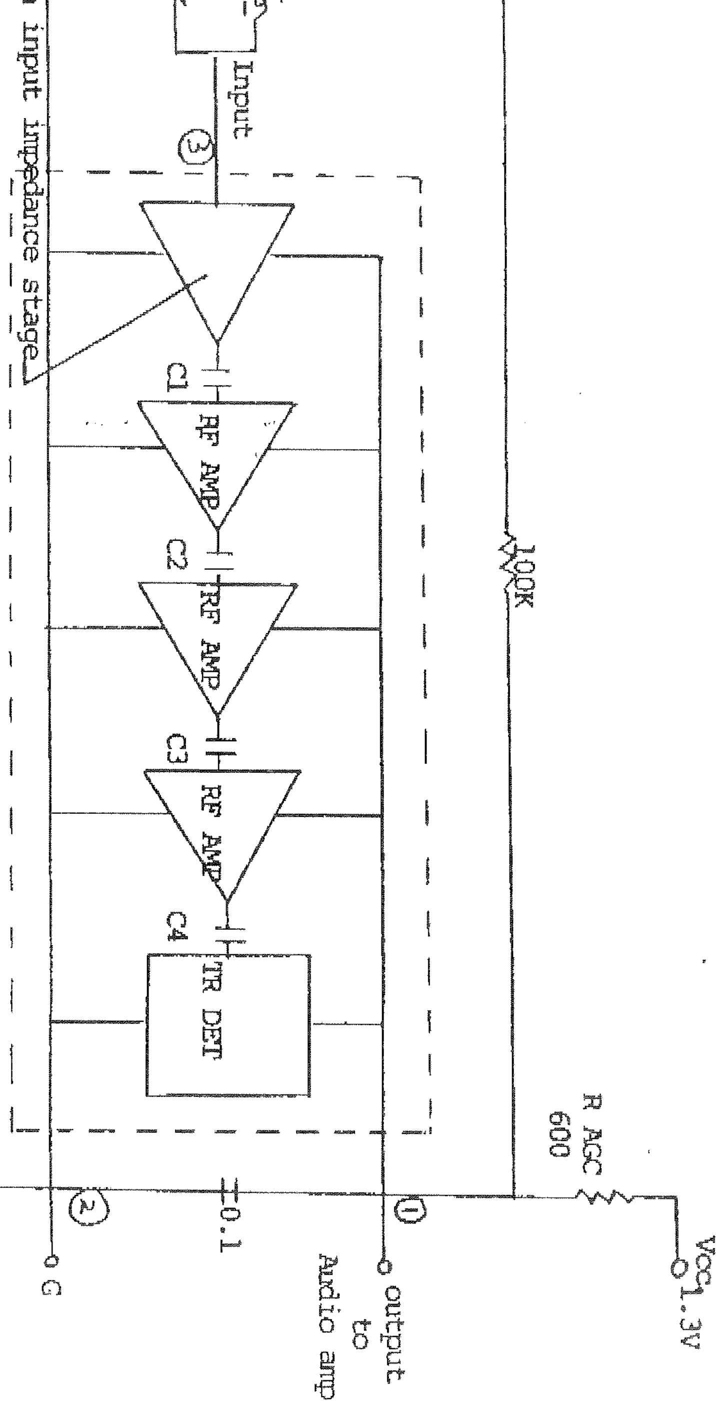
MEASURING CIRCUIT

FOR HIGH IMPEDANCE CIRCUIT



APPLICATION





MK-484 is within the dotted area

CHARACTERISTIC :

: above 1.1v

put Voltage : 1.0 - 1.5v

ut Current : 0.3mA typ.

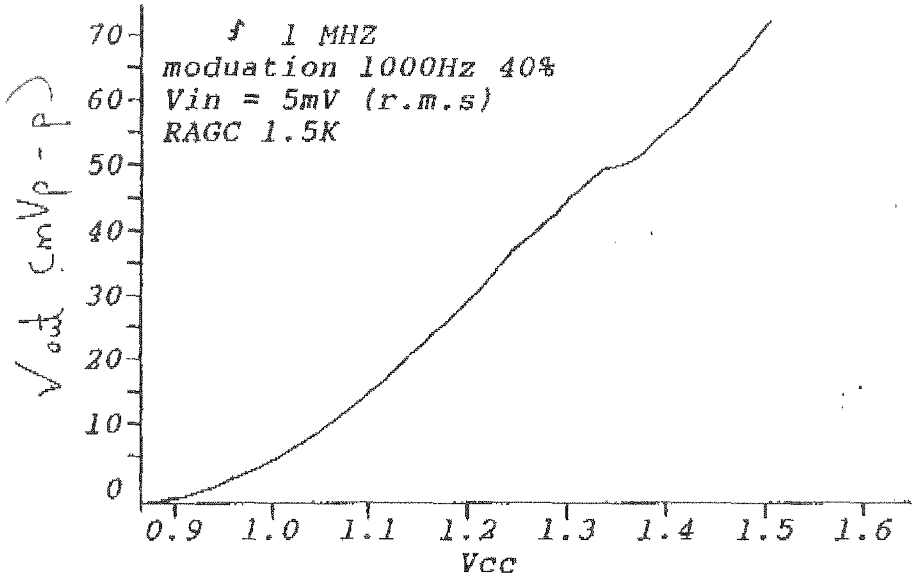
4. f : 300K -3MHZ

5. Input Resistance: 4MΩ typ.

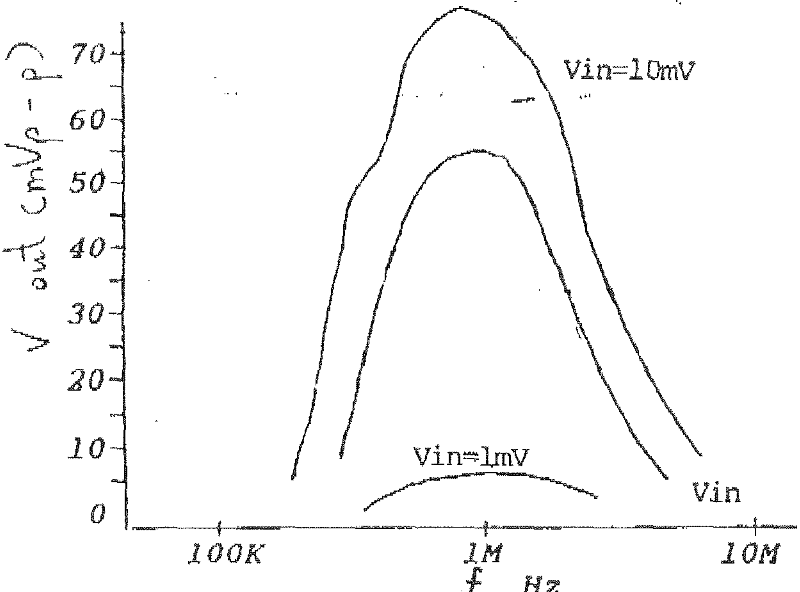
MAXIMUM RATINGS :

OPERATING TEMPERATURE	*SYMBOL*	*RATING*	*UNIT*
OPERATING TEMPERATURE	*Topr*	*-30 - +80*	*°C*
STORAGE TEMPERATURE	*Tstg*	*-40 - +125*	*°C*
SUPPLY VOLTAGE	*Vcc*	*1.5*	*V*

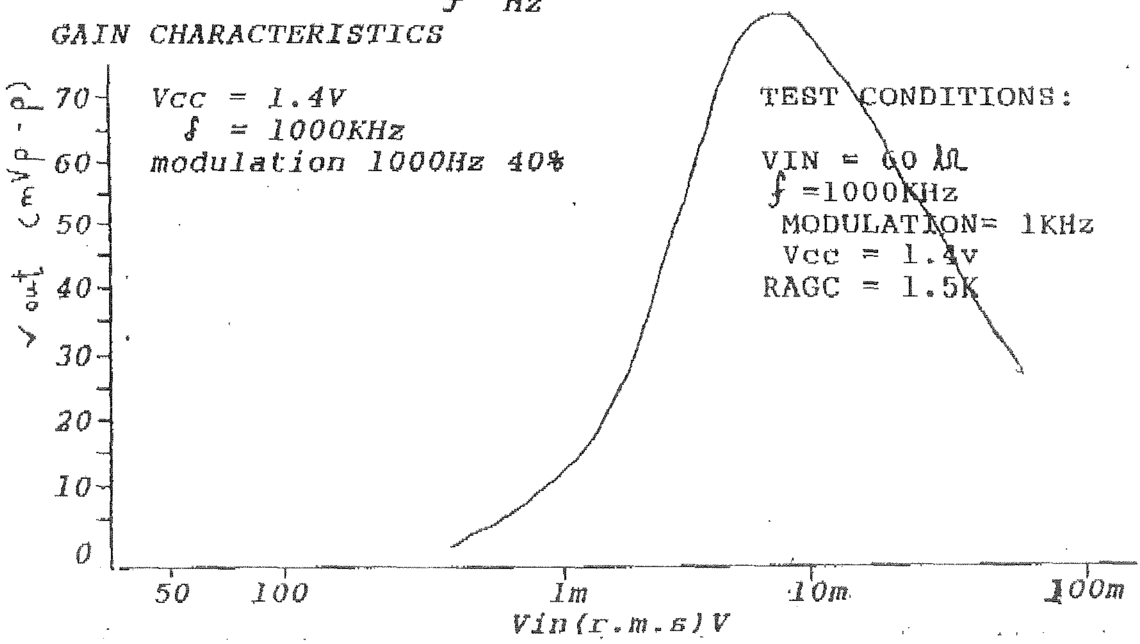
GAIN VARIATION WITH SUPPLY VOLTAGE



BANDWIDTH CHARACTERISTICS



GAIN CHARACTERISTICS



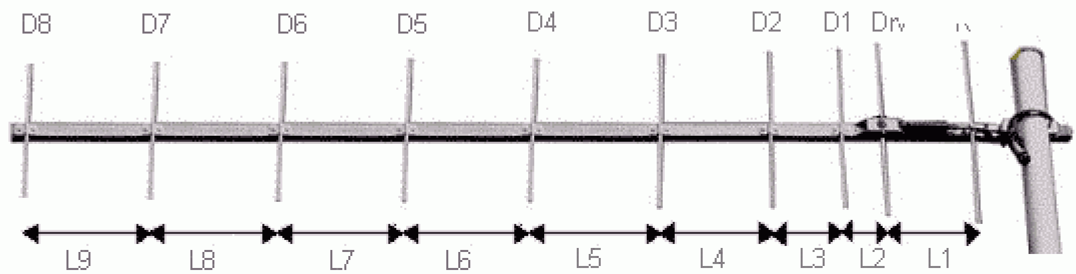
Home made UHF Yagi Antennas
RE-A430Y10

By Guy, de ON6MU

Optimized 10-element UHF Yagi Antenna

10 element UHF antenna

de ON6MU



Technical specs

Forward gain = 11,82 dBd
Front/Back ratio = 22 dB
SWR at 435 MHz = 1:1
Frequency range = 430...440MHz
Horizontal angle = 33°
Vertical angle = 38°

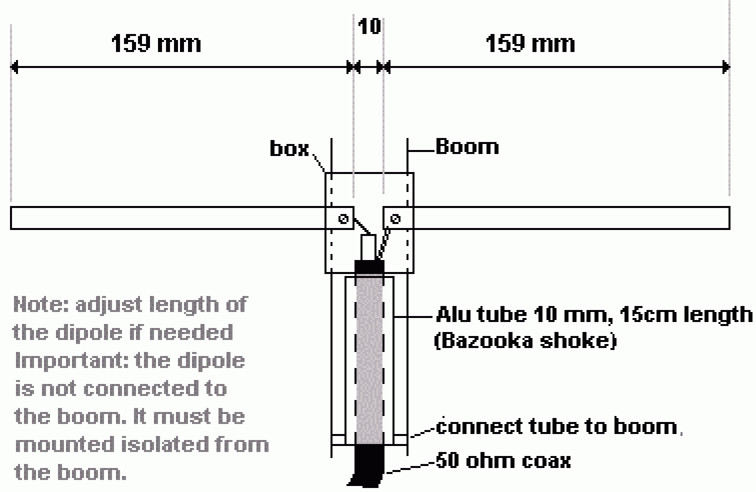
Length of the elements

R = 348 mm
Drv= 328 mm
D1 = 302 mm
D2 = 298 mm
D3 = 292 mm
D4 = 287 mm
D5 = 285 mm
D6 = 282 mm
D7 = 280 mm
D8 = 276 mm

Spacing

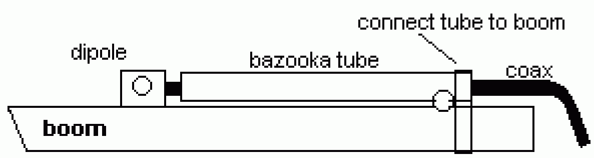
L1 = 145 mm
L2 = 50 mm
L3 = 124 mm
L4 = 149 mm
L5 = 173 mm
L6 = 194 mm
L7 = 208 mm
L8 = 217 mm
L9 = 225 mm

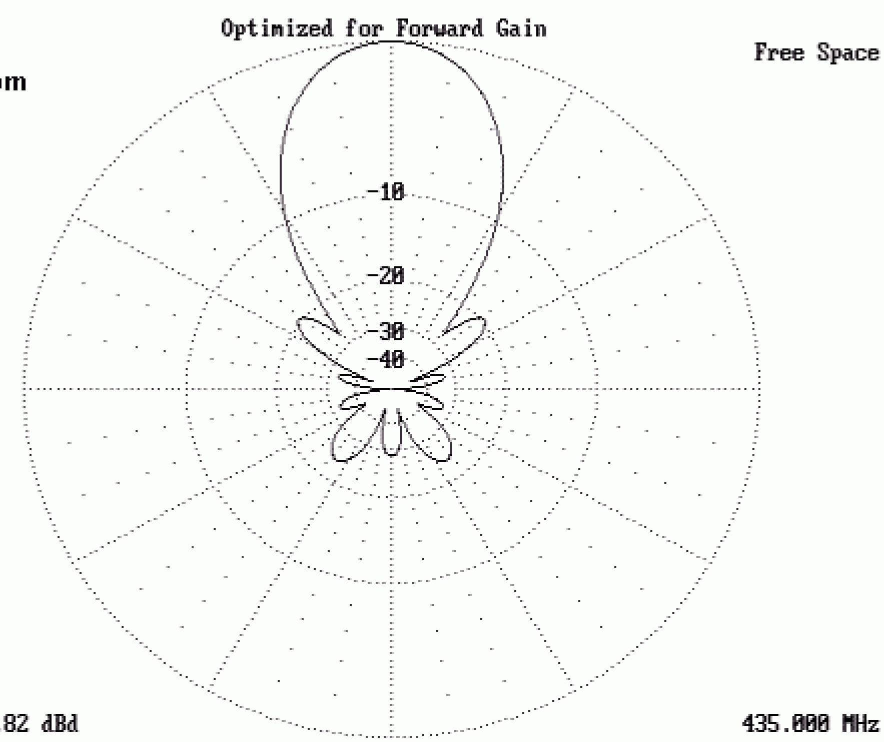
1.5 meter boom needed



Note: adjust length of the dipole if needed. Important: the dipole is not connected to the boom. It must be mounted isolated from the boom.

You can also use a folded dipole with a 1:4 balun (see my site for more info about building a balun)instead of a open dipole. To fine tune the SWR (in both cases) by in- or decreasing the dipole length or by moving the dipole between the first director and the reflector a bit. Sometimes it can help by changing the connection points on the dipole (connecting the coax a bit of the center).





Horizontal stacking distance: 1075 mm
Vertical stacking distance: 933 mm

The elements diameter of the antenna may vary between 5...10mm and the dipole diameter may vary between 8...12mm (12mm recommended) without the need of changing anything to the length or spacing.
All elements except the dipole are electrically connected to the boom and may be mounted on top or through it.
The thickness/diameter of the boom may vary between 10...17mm.
Bazooka tube (RF choke to prevent rf wave currents): not critical, as long as it fits the coax snugly; examples: 15cm long 10mm diameter (for Aircel etc.), 15cm long 15mm diameter (for H100, Aircom+ etc.). Or you can use a few ferrite beads placed over the coax directly behind the driver instead.
Use a piece of isolator type boom (plastic tube, wood, fiberglass) of +/- 40cm if you mount the antenna vertical to prevent distorion of the radiation pattern.
The ideal SWR can vary a bit if the elements are isolated, raised from the boom or do to construction. A bit of experimentation with the driver length can solve this easily.
Note: the antenna can also be tuned between approx. 428...446MHz by adjusting the driver

Images of the 70cm Yagi antenna,
How Greg **SP5LGN** made it

Click to enlarge



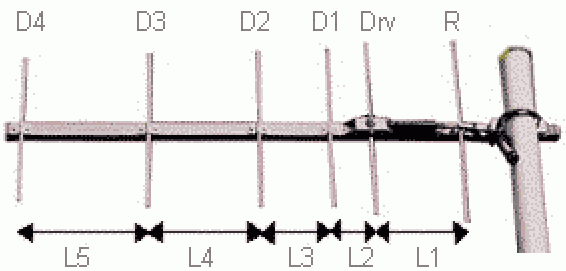



Thanks Greg for the photo's!

Optimized 6-element UHF Yagi Antenna RE-A430Y6

70cm UHF 6ELEMENT YAGI ANTENNA

de ON6MU



Technical specs

Forward Gain = 9dBd
Front-Back ratio = 13dB
SWR at 435MHz = 1:1
Bandwidth = 10MHz
Frequency range = 430...440MHz

Length of the elements

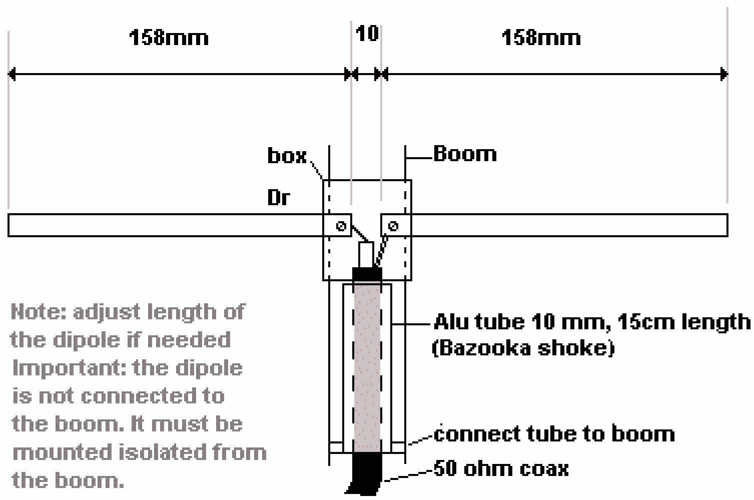
R = 346 mm
Dr = 326 mm
D1 = 302 mm
D2 = 298 mm
D3 = 292 mm
D4 = 288 mm

Spacing of the elements

L1 = 128 mm
L2 = 55 mm
L3 = 124 mm
L4 = 149 mm
L5 = 174 mm

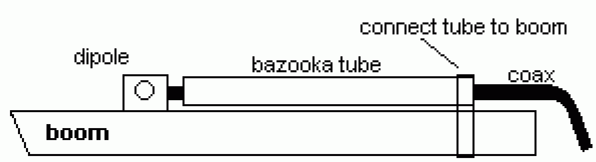
Used material

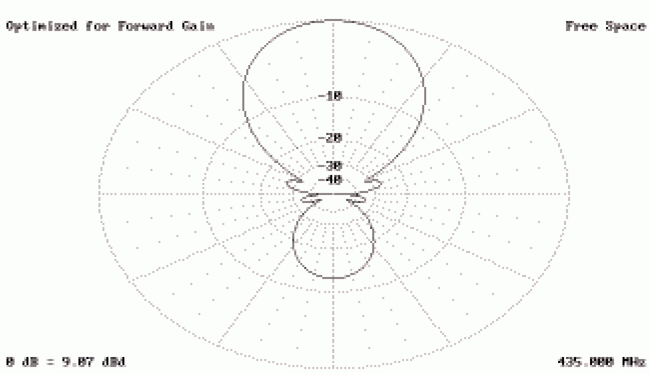
Aluminum tubes of 8 mm Ø
Boom = 15 x 10 mm
15 cm alu tube Ø 10 mm for aircel or RG-58 coax. Use O 15 mm for RG213, H-100, Aircom.



Note: adjust length of the dipole if needed
Important: the dipole is not connected to the boom. It must be mounted isolated from the boom.

You can also use a folded dipole with a 1:4 balun (see my site for more info about building a balun)instead of a open dipole. To fine tune the SWR (in both cases) by in- or decreasing the dipole length or by moving the dipole between the first director and the reflector a bit. Sometimes it can help by changing the connection points on the dipole (connecting the coax a bit of the center).





The elements diameter of the antenna may vary between 5...10mm and the dipole diameter may vary between 8...12mm (12mm recommended) without the need of changing anything to the length or spacing.
All elements except the dipole are electrically connected to the boom and may be mounted on top or through it.
The thickness/diameter of the boom may vary between 10...17mm.
Use an isolator type boom (plastic tube, wood, fiberglass) if you mount the antenna vertical to prevent distorion of the radiation pattern.

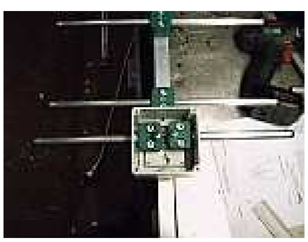
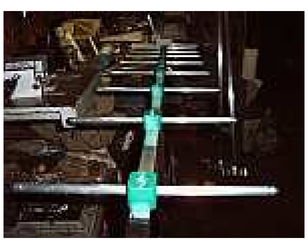
Pictures and details of the optimized UHF Yagi antenna 430 Mc to 440 Mhz (420 Mc to 450 Mc @ 1:2 SWR)

- Michel F1SRC and how he made it: http://f1src.free.fr/antenne/yagi/yagi_6el_70cm.htm
-
- How Greg SP5LGN made it

  Click to enlarge

Thanks Greg.

- How Geert ON3GVG made the antenna:

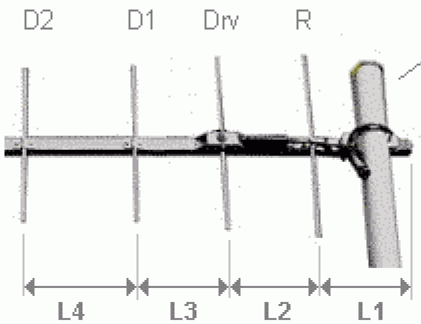
Note from Geert: he made the driver a few mm smaller to obtain an obtimum SWR in the band segment.
Thanks Geert!

Optimized 4-Element UHF Yagi antenna RE-A430Y4

de ON6MU

UHF 70cm 4-element long Yagi

de ON6MU



Note: use plastic tube if antenna is mounted vertically!

Technical specs

Forward gain = 7,6 dBd
Front-Back ratio = 14 dB
SWR at 435MHz = 1:1
Bandwidth = 10MHz
Frequency range = 430...440MHz

Element length in mm

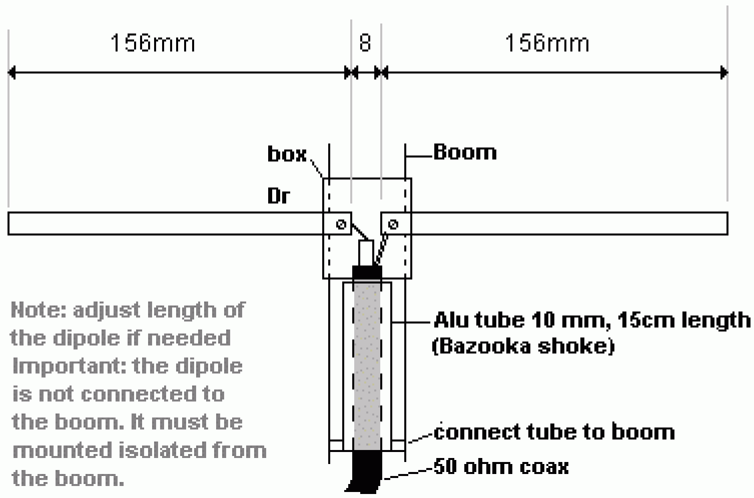
R = 342
Drv = 320
D1 = 300
D2 = 284

Element spacing in mm

L1 = 100
L2 = 120
L3 = 115
L4 = 150
Total boomlength = 485 mm

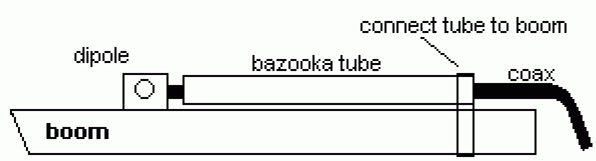
Used material

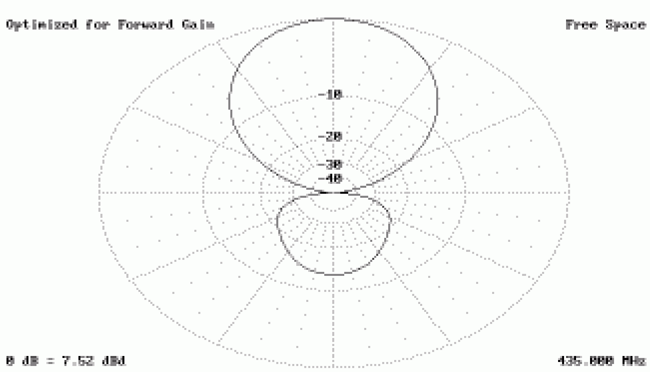
Aluminum tubes of 8 mm
Boom = 15mm x 10mm
Bazooka tube = 15cm Ø10mm (for aircel)
15cm Ø15mm (for H-100, RG-213, Aircom...)



Note: adjust length of the dipole if needed
Important: the dipole is not connected to the boom. It must be mounted isolated from the boom.

You can also use a folded dipole with a 1:4 balun (see my site for more info about building a balun)instead of a open dipole. To fine tune the SWR (in both cases) by in- or decreasing the dipole length or by moving the dipole between the first director and the reflector a bit. Sometimes it can help by changing the connection points on the dipole (connecting the coax a bit of the center).

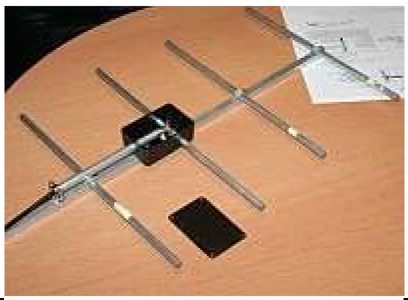




The elements diameter of the antenna may vary between 5...10mm and the dipole diameter may vary between 8...14mm (12mm recommended) without the need of changing anything to the length or spacing. All elements except the dipole are electrically connected to the boom and may be mounted on top or through it. The thickness/diameter of the boom may vary between 10...17mm.

The ideal SWR can vary a bit if the elements are isolated, raised from the boom or do to construction. A bit of experimentation with the driver length can solve this easily.
Bazooka (RF choke): you can also use a few ferrite beads placed over the coax directly behind the driver instead.

Image of the 70cm Yagi antenna,
How dr Sasa Vasiljevic made it


Thanks Sasa!

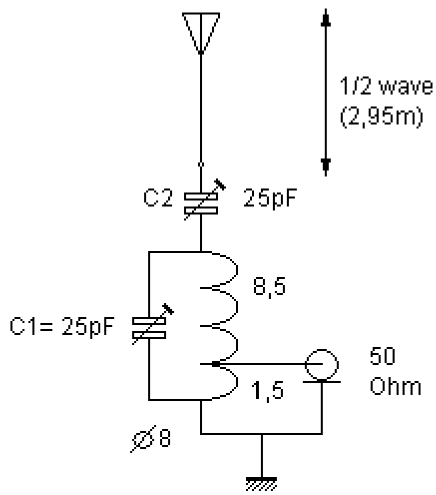
Home

ON6MU

VHF 1/2wave vertical antenna for the 6-meterband (50 Mhz)
RE-A50V12

By Guy, de ON6MU

Schematic fig1



1/2 wave antenna principle

A much better type of antenna then a simple quatre wave and that has more gain is the 1/2 wavelength vertical. We know that the impedance of the 1/2 dipole is 70 Ohms when we attach the coax in the middle, but what if we were to attach our coax directly to the end? The impedance at this point is high, very high, so we must make a matching device to match the antennas impedance to the 50 Ohm coax. What would happen if we did not use this matching device? Well...you would know that this would result in a very very high SWR.
The bandwidth of these antennas are good, they can easily span the entire 50Mc band and more with a low SWR. But, in this design, the bandwidth is limited to approx. 600kc (without re-tuning C1 or C2). This allows you to tweak the antenna to your desired band and avoid interference and reduce intermodulation.
The antenna and ground are connected across the tuned circuit while a 50-ohm coaxial cable is connected to taps on the inductor. The tuned circuit presents a high impedance to the antenna and the tapped inductor steps this impedance down to 50 ohms. Adjusting the tuning capacitor tunes out slight reactance variation if the antenna is not an exact electrical half-wavelength.

Parts list

- 4 pieces of 1 meter alu or copper tubing:
  - one 18 mm diameter
  - one 15 mm diameter
  - one 12 mm diameter
  - one 10 or 8 mm diameter
- 1 female PL 259 chassis
- some cul wire (isolated wire like from a transformer etc.) of 0,8 mm thick
- a coil holder of 8 mm diameter
- two 25pF regulable capacitors
- A robust PVC box of approx 30x50x18 mm and 2mm or more thick
- a piece of hard insulating material that snuggly fits inside the base tube, like:
  fyberglass, nylon, hard pvc, hard wood, bamboo etc... as long as it's very strong, stress and weather resistant.
- and a few innox hose clamps

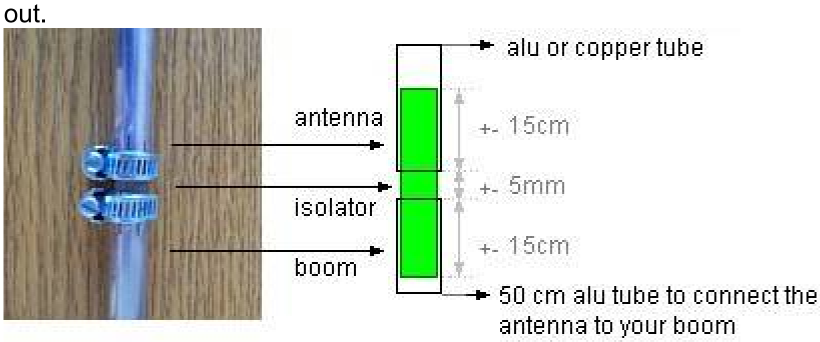
Note: there are many ways to build your antenna and I'm sure some can come up with better mechanical designs then described here although the design and material used here is cheap and easy to find. Also, the diameters of the tubing described here is not too critical.

Links of interest:

The antenna

- Construction:
  The vertical itself is constructed out of four overlapping sections of aluminum tube whose sizes are given.

  - saw the 1 meter 18 mm alu tube in half. One part (50 cm) will be used as a boom and the other as the first part (also 50cm) of the antenna.
  - saw some grooves (approx 1,5 cm) in both halves of the tube to allow a hose clamp to tighten everything up.
  - same goes for the other tubes that fits inside eachother. All tubes are firmly fixed together by using hose clamps.
  - Measure from the base up 2,95 meters. You can alwyas tune the antenna to its best SWR by sliding the top tube in or out.



  - saw a piece of that hard insulating material of your choice and fit it 10 cm in the antenna and boom part and leave a gap of 3 mm between them.
  - hammer down one end of each of the 3 radials (3 x 22 cm) so it becomes a bit flatten. This will make things easier to screw tight with the hose clamp. These radials are fitted on the boom section.

- The little black box:

Here is where all the secrets are stored HI. I used a little plastic box where I placed the LC-circuit and the PL connector.
I also drilled two little holes where you can regulate the two capacitors with an little isolated screwdriver. Afterwards you can seal the holes up to prevent moisture from entering the box.

- The LC tank-circuit:
- Wind 10 turns of 0,8mm cul wire around the 8mm coil holder and make a tap at 1,5 turns. There is no spacing between the windings.
- The smallest part (the "cold side" 1,5 turns) of the coil is where your centre part of the connecor/coax is connected to. The above schematic shows how.

- As you can see there are two wires comming out of the box (which contains the LC): one for the antenna and the other for the ground (being the connecting boom piece).


- Connect the wires accordingly and be sure to seal everything up.

- Tuning:
- Get your old (t)rusty SWR-meter and and some 50 Ohms coax and connect your transceiver to it.
- Set the two capacitors to halfway to start with.
- Mount your antenna temporary 1,5 meters from the ground for the first tests and measure the antenna length (the boom piece NOT included) at 2,95 meters and try to ground the boom.
- Find a CLEAR frequency and set your transceiver to MINIMUM possible power and use a carrier type modulation (CW, AM, FM).
- Tune C1, which is the most important and critical capacitor, till the SWR gets a s low as possible on your desired centre frequency (51 Mc)
- Then tune C2 till the SWR is even more lowered or even 1:1.
- Repeat the last two steps at location if needed
- Fine tuning your antenna can be done by sliding the tubes in or out. Sometimes when your place your antenna higher or when the antenna has obstacles in its proximity the SWR can vary from the one you noted first. Raising or lowering the length of the antenna should fix it.

Highlighted

Specifications ON6MU Vertical Antenna RE-A50V12

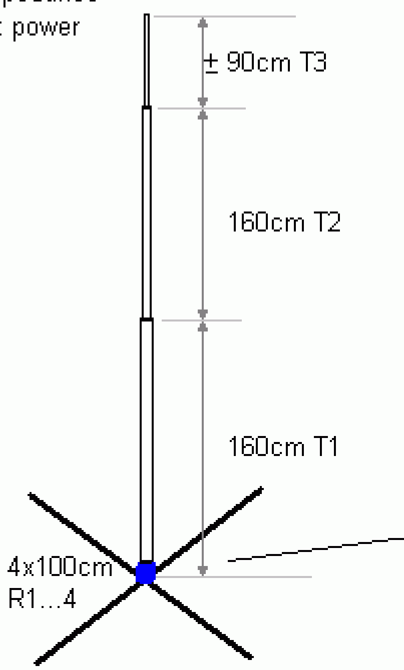
- Total length (including the 50cm mounting boom piece): 3,5m (2,95m effective)
- centre frequency: 51 Mhz
- bandwidth: 2 Mhz
- maximum tunable frequency range: 49...53 MHz+-
- impedance: 50 Ohms
- Gain: 3,6 dBi
- Maximum power using the components described: 20 watt
- NO counterpoise or radials needed if the boom is grounded or the boom length is >= 1,5m
- DC grounded (no static buildup)
- Height: 2,95m
- If needed, it can be disassembled into a very small bundle no longer than the longest element.

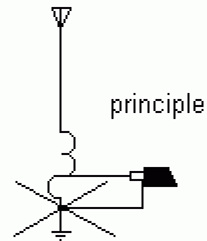
Be sure to seal everything up to avoid moisture, corrosion etc...

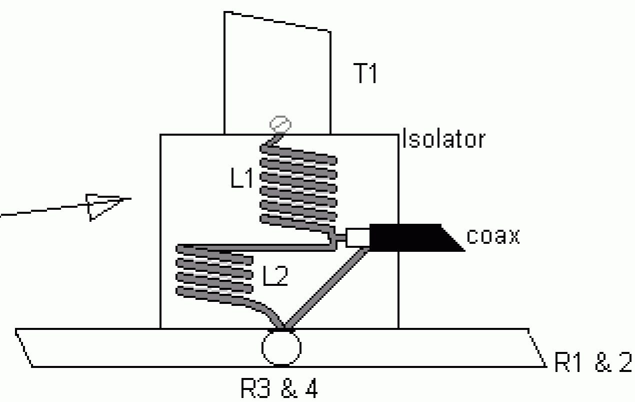
5/8 vertical groundplane antenna for 50MHz RE-A50V58

5/8 vertical groundplane antenna for 50 MHz,

Omnidirectional pattern
4.7dBi gain
2 MHz Bandwidth at 1.5 SWR
1:1 SWR on center frequency
50 OHm impedance
200 W max power







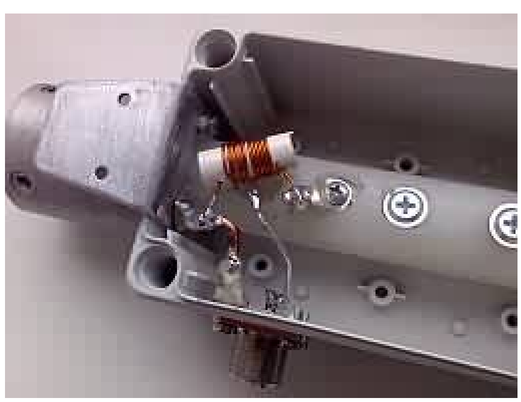
T3 = 10mm Ø (tune for best SWR by sliding it in or out T2)
T2 = 15mm Ø
T3 = 20mm Ø
R1...4= four tubes of 1 meter or 2 tubes of 2 meter crossed Ø 8mm or Ø 10mm
All alu tubing

L1 = 7 t 0.8mm, coil Ø 10mm
L2 = 5 t 0.8mm, coil Ø 10mm

de ON6MU

Note: If using a grounded boom, you can leave out the radials R1...R4 or shorten them to approx. 4x30cm

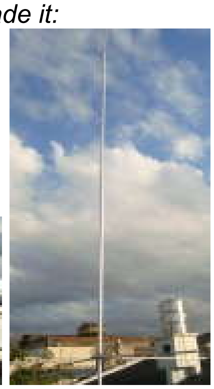
This is how Greg, **SP5LGN** constructed my 5/8 lambda 6-meter GP antenna:



Click to enlarge
Many thanks Greg!

How Horacio LU9DFN made it:

Click to enlarge
Many thanks Horacio!

SWR:
You can fine-tune the SWR to peak in the bandsection you are planning to use the 5/8 groundplane antenna by:

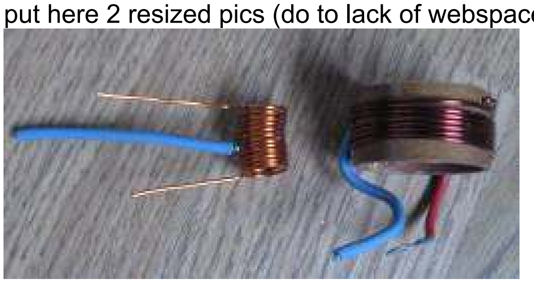
- - shorten or lengten the radiating element (vertical section)
- - shorten the radials
- - experiment with the coil spacing

Today's specials:

.**ON6MU Homebrew projects**
.Radioamateur related projects

.**ON6MU Ham mods**
.Modifications of transceivers

PA3BEN sent me a lot of pics on how to convert an old CB antenna using my schematic (shown here above) for 50Mc! I've put here 2 resized pics (do to lack of webspace, sorry):



Thanks Ben!

[Please take a look at my 50mc wide-spaced yagi antenna]

ON6MU

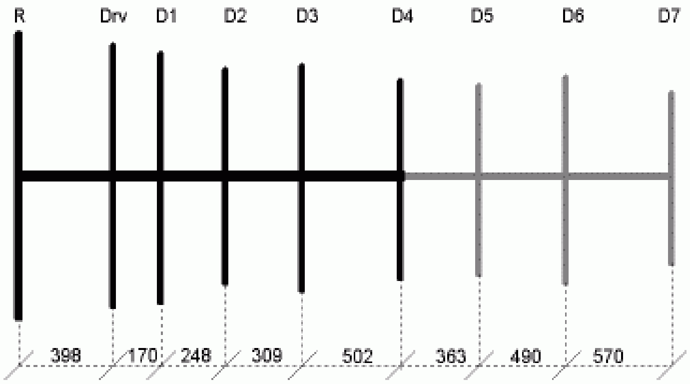
Home

Optimized 6/9 element VHF Yagi Antenna
RE-A144Y6/9

By Guy, de ON6MU

Optimized 6/9-ELEMENT VHF YAGI
de ON6MU

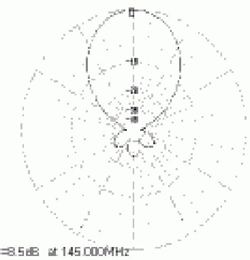
Fig.1:Top view



Element	Length	Prog. Spacing
Reflector	1014	0
Driver	980	398
Director 1	946	568
Director 2	882	816
Director 3	904	1125
Director 4	876	1627
(Director 5	870	1990)
(Director 6	900	2480)
(Director 7	830	3050)

Boom +- 20 x 20 mm.
Aluminum tubing for all elements and 10mm. thickness except for the reflector that's 12mm. thickness.

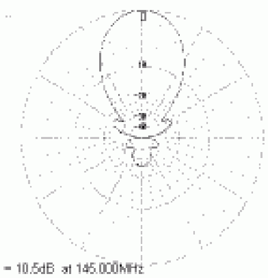
Fig.5: Antenna pattern 6-element



Specifications 6-element

Forward Gain	= 8.5 dBd
Front-to-Rear ratio	= 26 dB
SWR on 145 MHz	= 1
SWR on 144 & 146 MHz	= 1.2
Ver.-plane pattern	= 53°
Hor.-plane pattern	= 42°
Max. bandwidth	= 4MHz

Fig.6: Antenna pattern 9-element



Specifications 9-element

Forward Gain	= 10.5dBd
Front-to-Rear ratio	= 26 dB
SWR on 145 MHz	= 1
SWR on 144 & 146 MHz	= 1.2
Ver.-plane pattern	= 40°
Hor.-plane pattern	= 34°
Max. bandwidth	= 4MHz

Fig.2: Example of an aluminum bracket to mount SO-239 or N on boom

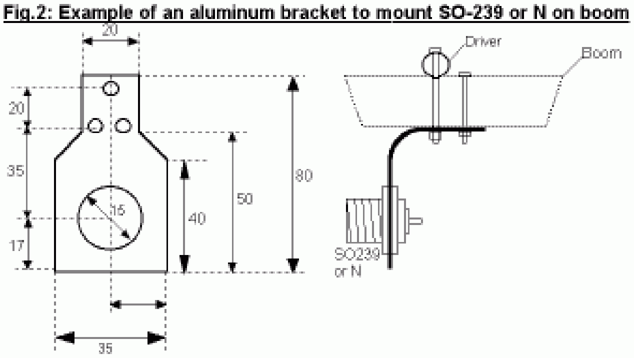


Fig.3: GAMMA MATCH with concentric tubing

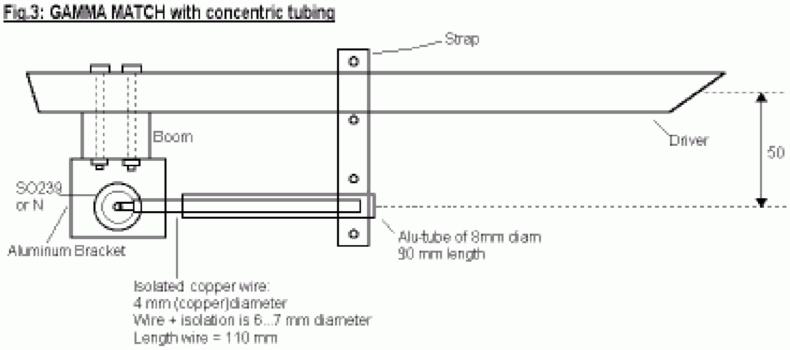
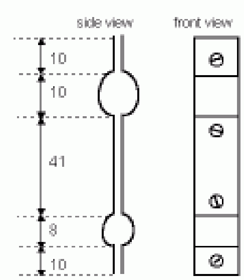


Fig.4: Aluminum Strap



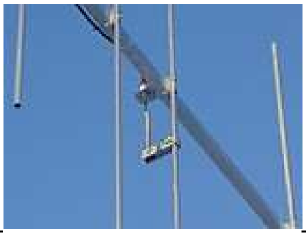
Notes:
All elements are connected to the boom directly (NOT isolated from the boom). You may mount them on top of the boom or through the boom.
Regulate the Gamma-match until best SWR is found on the desired center frequency by sliding the strap and/or Alu-tube.
Use some grease between all connections and seal everything up with silicone to prevent corrosion.

73" Guy, ON6MU

Note: the antenna can also be tuned between 142...148MHz

Pictures and details of the optimized VHF Yagi antenna

Greg SP5LGN, and how he made it:


click to enlarge the images

How Luc ON5DL made it:



he made this antenna in two hours!

click to enlarge the images

How Geert ON3GVG made it:



Thanks Geert!

Charles KC8VWM and how he made my optimized VHF Yagi Antenna RE-A144Y6/9:

ON6MU 9el Yagi Antenna Design

The computer optimized 9 el. homebrew antenna is performing very well. I have made many long distance contacts using the ON6MU VHF Yagi antenna. I have the antenna located only 35 feet above the ground. (See antenna photo titled KC8VWM to see how high it is mounted on my house.)

The very first day I put up the ON6MU antenna, I contacted two stations in Toronto Canada which is located 507 km. away from me. Other stations I contacted were located in other states like Buffalo, New York, Pennsylvania, Indiana, Tennessee, Michigan, and West Virginia.

I was also picking up weak EME signals later that evening on 144.127 MHz. using mode JT65B.

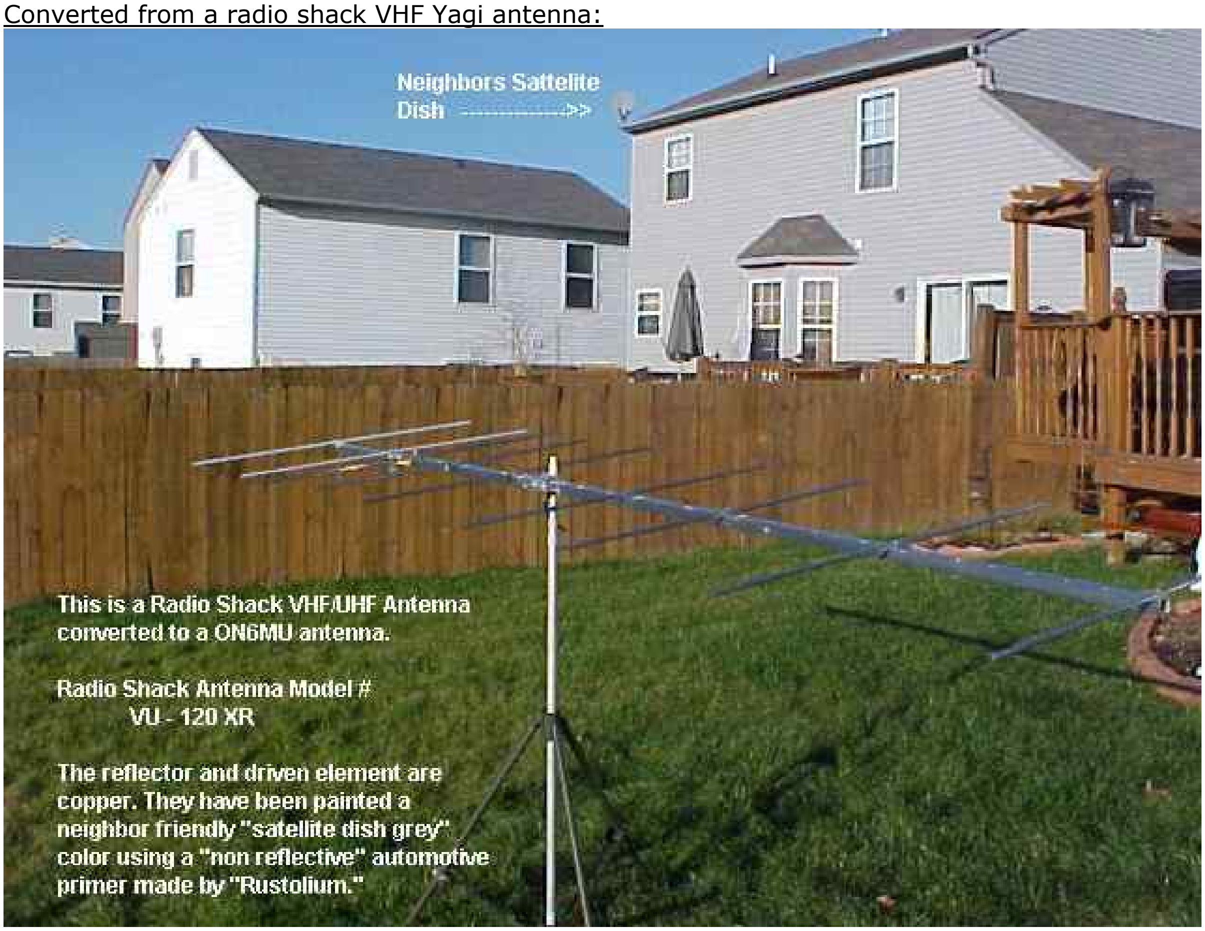
Back to front and measurements:

Checking Element Alignment Element Mounting Method

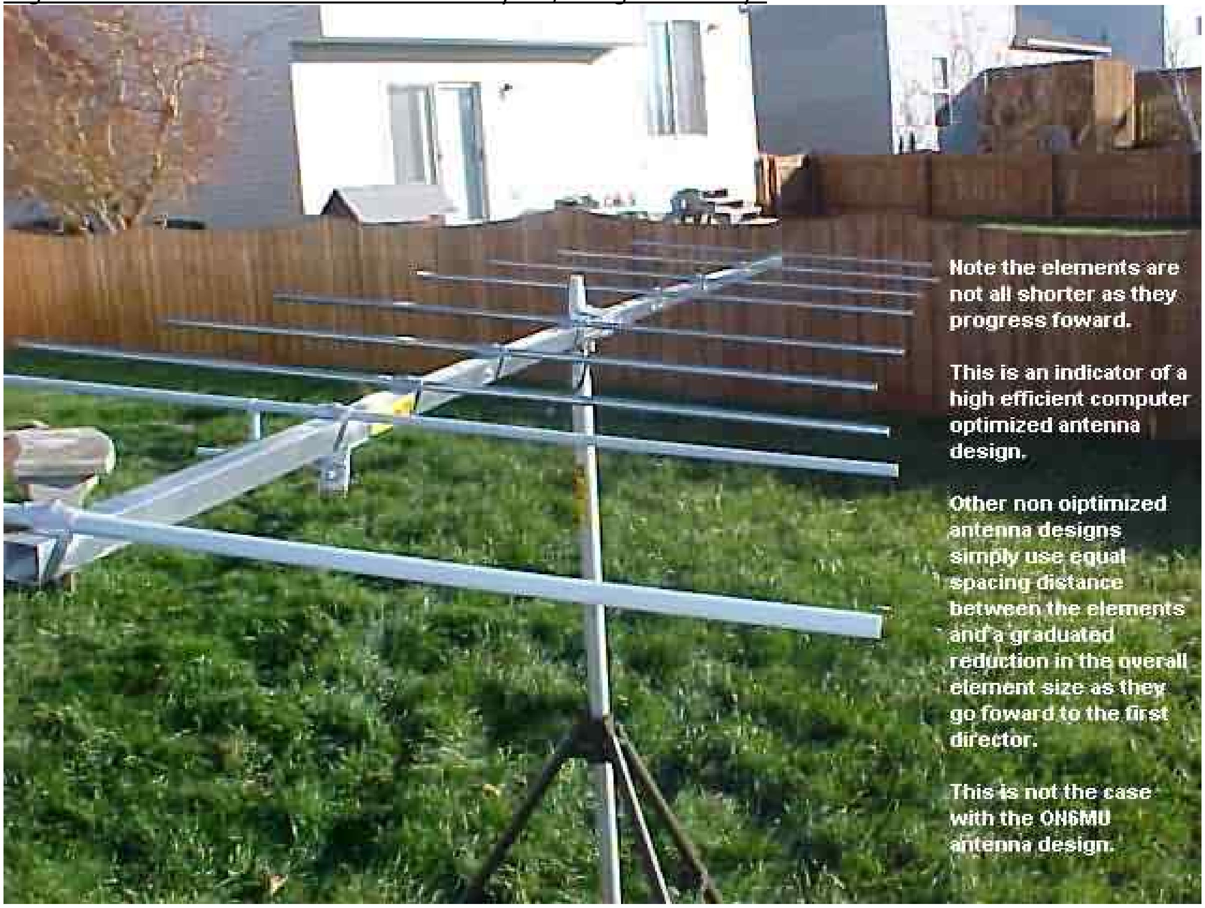
Gamma Match Closeup

Gamma match mounting

Converted from a radio shack VHF Yagi antenna:



Right side view: notes on the element layout/design and why:



Left side view: tuned and ready to install

KC8VWM QTH: the ON6MU VHF optimized antenna mounted on top of the roof

The original TV antenna model (Radio Shack VU 120 XR) I used for the entire construction of the ON6MU antenna design can be found here:

http://www.hdtvprimer.com/ANTENNAS/VU-120XR.html

73

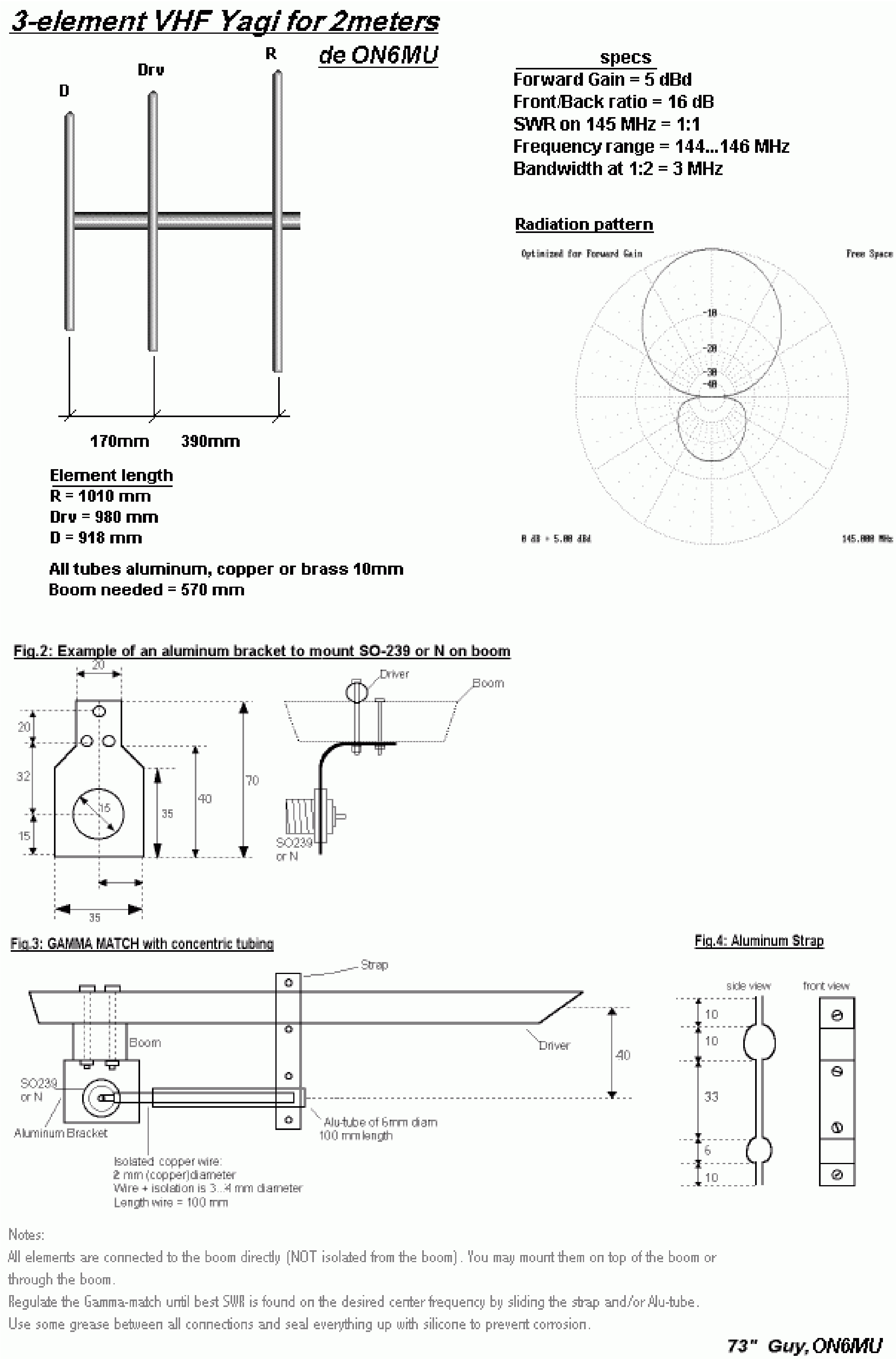
Charles KC8VWM

Thank you for the feedback and photo's Charles!

My Yagi 9-element version
made by ON2BJS

Thanks Bechir

3-element VHF homemade (portable) yagi RE-A144Y3



Note: the antenna can also be tuned between 142...148MHz

Details


Pictures on how SWL Voiculescu Eduard made it.
click to enlarge
Thanks Eduard!

These are some examples of PA0CDR



click to enlarge
Thanks Gerlof

More projects:

ON6MU
HOME

Three types of multi-functional Homebrew 10-, 20- and 30 Ampere regulatable power supplies: RE PSR28A10, PSR30A20 and PSR30A30

RE-PSR28A10

By Guy, de ON6MU

This is an easy to make power supply which has stable, clean and regulatable output voltage. By using a MOSPEC MJ15003G transistor which is capable of delivering 20A which is 2 times the amount of amps the power supply is designed for, making it really though to brake ;). Make sure you mount the transistor on a huge heat sink. Also use thick wires.

Although the LM-317 power regulator will kick in on shortcircuit, overload and thermal overheating, the fuses in the primary section of the transformer and the fuse F2 at the output will secure your power supply. The rectified voltage of: 30 volt x SQR2 = 30 x 1.41 = 42.30 volt measured on C1. So all capacitors should be rated at 50 volts. Caution: 42 volt is the voltage that could be on the output if one of the transistors should blow.

P1 allows you to set the output voltage to anything between 0 and 28 volts. The LM317 lowest voltage is 1.2 volt. To have a zero voltage on the output I've put 3 diodes D7,D8 and D9 on the output of the LM317 to the base of the MJ5003J transistor. The LM317 maximum output voltage is 30 volts, but using the diodes D7,D8 & D9 the output voltage is approx 30v - (3x 0.6v) = 28.2volt.

Calibrate your build-in voltmeter using P3 and, of course, a good digital voltmeter.

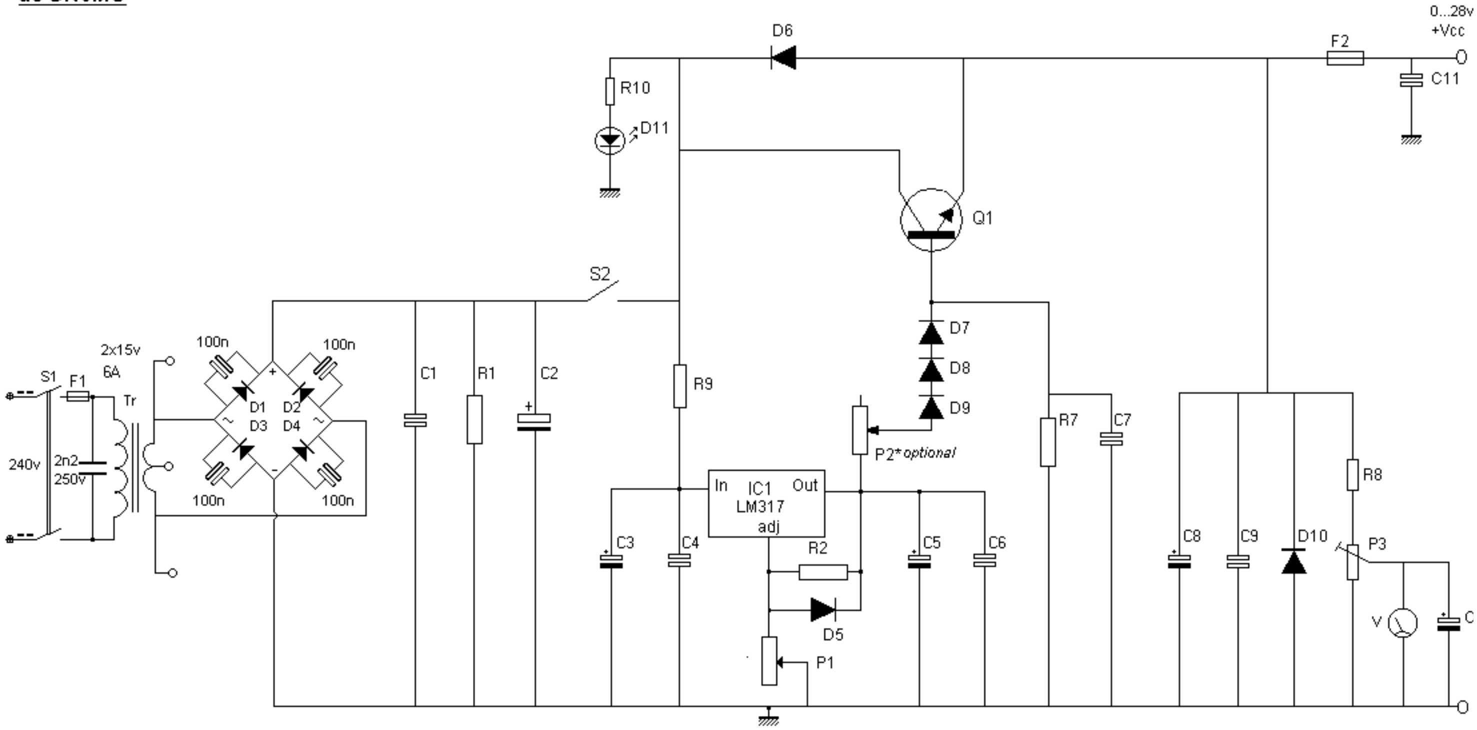
P2 will allow you to set the limit of the maximum available amps at the output +Vcc. When using a 100 Ohm/1watt varistat the current is limited to approx. 3 Amps @ 47 Ohm and +- 1 Amp @ 100 Ohms. You can leave it out completely if no limmiting is needed.

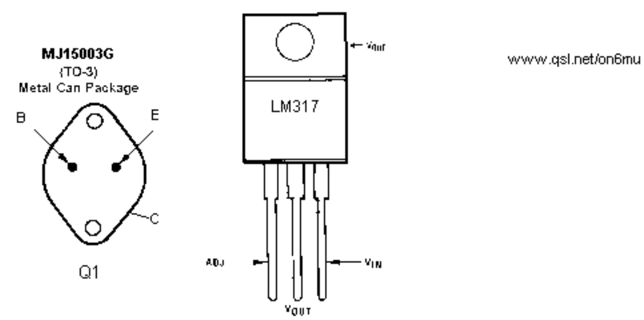
Note:
Be sure you isolated the transistor from the heatsink if you are using a metal casing where you electrically mount the heatsink to it.
Remember to use thick wires suitable for transfering the current needed according to the power supply you tend to build.

RE-PSR28A10 Power supply Schematic 1

10 Ampere 0...28 volt regulated power supply

de ON6MU





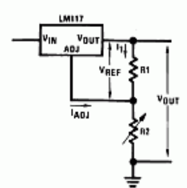
Part list for 6/8 Amp regulatable power supply (PSR28A68):

- 2 x 15 volt (30volt total) 8...10 amps
- D1...D4 = four MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 2 x 4 1N5401 (1N5408) diodes.
- F1 = 1 Amp (slow)
- F2 = 12 amp
- R1 2k2 2,5 Watt
- R2 240 ohm
- R7 6k8
- R8 10k
- R9 39 0.5 watt
- R10 8k2
- C1,C7,C9 47nF
- C11 22nF
- C2 10000uF/50v
- C3,C5 10uF/50v
- C4,C6 100nF
- C8 330uF/50v
- C10 1uF/16v

- D5 1N4148, 1N4448, 1N4151
- D11 LED
- D6, D7, D8, D9, D101N4001
- IC1 LM317
- MJ15003G MOSPEC transistor
- P1 5k
- P2 47 Ohm or 220 Ohm 1 watt *
  (be sure you can reach 0 ohms as any resistance limits the current)
  note:*This way of limiting the current is very basic, not an accurate way. To really get an accurate current limitter we need to modify the schematic around the LM317. P2 has been used to show a simple way of limitting, it is not the ideal way, but it works. When I have time I will look into this and place an update on the website.*
- P3 10k trimmer
  Calibration:
  - Get your hands on a calibrated digital meter or a good analog meter and measure the voltage at the output of the power supply.
  - Turn P1 to maximum (maximum voltage of our power supply).
  - Adjust P3 till the meter needle shows maximum result (end scale)
  - If you want to calibrate the scale, turn P1 to several voltages (like every volt) and confirm each time with your calibrated voltage meter. Make a mark on your power supply meter-scale to calibrate the meter.
  - You should see equal spaced voltage marks on your home-made scale if your meter is a linear type.

Less maximum output voltage needed?
In operation, the LM317 develops a nominal 1.25V reference voltage, VREF, between the output and adjustment terminal.
The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I1 then flows through the output set resistor R2, giving an
output voltage of

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right) + I_{ADJ}R2$$



Since the 100 uA current from the adjustment terminal represents an error term, the LM317 was designed to minimize IADJ and make it very constant with line and load changes.
To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

Less amps needed?
Well, without much modification you can:
- only one 2N3055, will give you 5 amps and have some amps/power to spare.
- the bridge rectifier (D1...D4) only needs 4 x 1N5401 (any +/- 3 amp diodes as only halve of the max. amp is needed, so we have some room when short-circuited)
- one 4700uF (C2) is sufficient
- F2 = 6 amp
- D5, D10 = 1N4001

The power supply insides

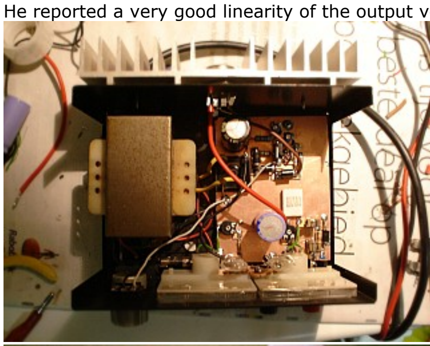
Heat sink

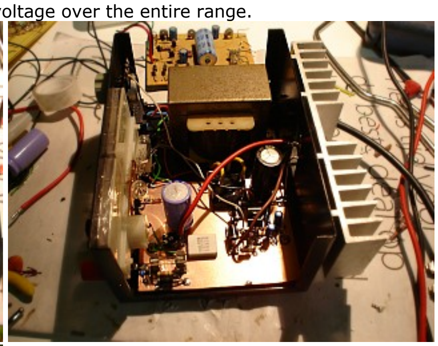
Remember to isolate the transistors from the chassis/radiator! Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.

Finished power supply:

This is how Oakkar7 made it (using a PC power supply chassis too!) :
Must see: http://okelectronic.wordpress.com/2011/07/08/diy-variable-workbench-power-supply/

Mark, PA4M, made a 3 ampere version by using just one 2N3055 and build into a Zetagi power supply box.
He reported a very good linearity of the output voltage over the entire range.



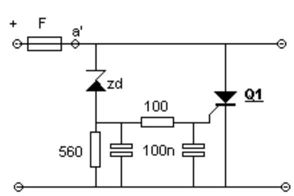


Thanks Mark for the feedback and pictures!

Overvoltage protection:

A crowbar circuit is an electrical circuit used to prevent an overvoltage condition of a power supply unit from damaging the circuits attached to the power supply. It operates by putting a short circuit or low resistance path across the voltage output (Vo), much as if one were to drop a crowbar across the output terminals of the power supply. Crowbar circuits are frequently implemented using a thyristor, TRIAC, trisil or thyratron as the shorting device. Once triggered, they depend on the current-limiting circuitry of the power supply or, if that fails, the blowing of the line fuse or tripping the circuit breaker.

The 'CROWBAR' overvoltage protection circuit (RF blocked)



Zd = zener xx Volt - maximum voltage to allow. For 12v PSU use Zd of 15v or 16v
Q1 = thyristor powerful enough to peak surge the current that the power supply delivers (times 10) hence blowing the fuse. Example:BTW69-600 (peak 600 Amp!)
Important: Be sure the power supply has a correct fuse!!

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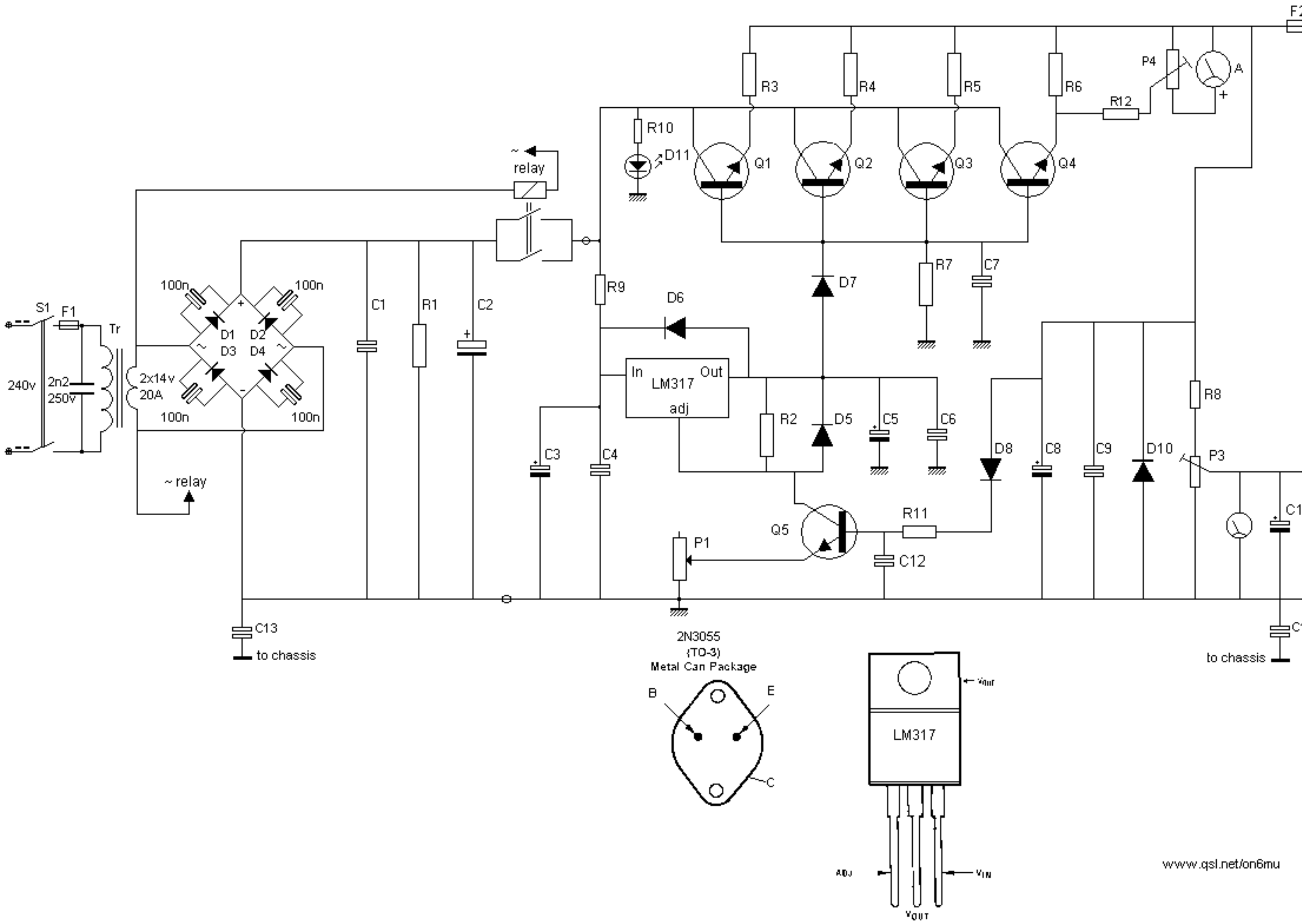
20 ampere regulatable power supply 1...30volt RE-PSR30A20

(total revision)

RE-PSR30A20 Schematic 2

20 Ampere 1...30volt regulatable power supply by ON6MU



Major revision of the entire project.

PSR30A20/30 Specs

- 1.35 volt ... 30 volts
- 20 ampere PSR30A20 (modify up to 30 amps PSR30A30)
- voltage stabilisation
- low ripple
- short-circuit protection
- option: current regulation
- HF immunity

Part list PSR30A20 or PSR30A30
20/30 Ampere regulatable power supply (30 amp version values in blue):

- 2 x 14 volt 20+- amps (30 amps)

- F1 = 2 Amp (4 amp)
- F2 = 25 amp (35 amp)
- R1 2k2 - 2,5 Watt
- R2,R12 240 ohm
- R3,R4,R5,R6 0.1 ohm 5 watt
- R7 6k8
- R9 10 1watt
- R8 10k
- R10: 10
- R11 4k7
- C1,C7,C9 47nF
- C2 five X 4700uF/50v or one 22000uF/50v
  C2 seven X 4700uF/50v or one 22000uF/50 + 10000uF/50v
- C3 10uF/50v
- C5 1uF/50v
- C4,C6,C10 100nF
- C8 220uF/50v
- C10 4.7uF/16v
- C11 2n2
- C12 22nF
- (C13,C14...100nF optional when using a metal chassis where the zero volt is islolated from)
- C15 100nF
- C16 10nF
- D1...D4= Bridge rectifier MB2504 (25 amps cooled)
  or eight BYW29 8 amp diodes (TO220 pinning cooled)
  or 8 x MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 16 x 1N5401 (1N5408) diodes.
- D5, D8 1N4148 (1N4448, 1N4151)
- D6 & D7 1N4001
- D10 1N5401
- D11 LED
- IC1 LM317
- Q1...Q4: Four 2N3055 transistors (six 2N3055) (you can also use the 2N3773 transistor)
- Q5 BC338, 2N2222, BC547
- P1 5k
- P3 10k trimmer
- P4 2k5 trimmer (to calibrate the meter at max current).
- optional: relay = 30 volts AC, 2x10 (3x10) amp switching

optional: *To get an accurate current limitter we need to modify the schematic around the LM317. When I have time I will look into this and place an update on the website.*

The relay is used to switch off the power supply voltage when the mains (S1) are/is switched off. So no delay do to the discharge of C2, and so preventing output voltages from not return to zero immediately. You can leave it out if you do not care about slow discharge of the voltage when turned off, or add a heavy duty secondary switch.

A MB2504 is used as it is a 25 ampere rectifier bridge which also should be cooled. Or you could use eight BYW29 8 amp diodes (TO220 pinning) mounted on a heat sink.

Mount a little heatsink on the LM317 IC. Be sure that C3, C4, C5 and C6 are mounted as close as possible to LM317!

Use heavy bread wires that can deliver 20/30 amps

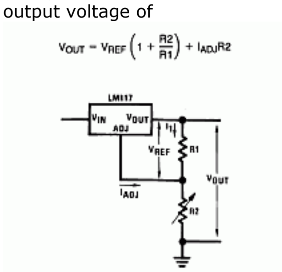
Remember to isolate the 2N3055 transistors from the chassis!
Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.

20/30 amp needs proper large heat sink and remember to use pretty thick wires!
Note:
The collectors of the finals needs to be soldered with a wire all together if the transistors even if they are isolated from the heatsink or not. If you do not isolated the finals from the heatsink, then please make sure the heatsink does not make contact with the chassis (metal casing where you plan to build the PS into).

This revision has been improved with a feedback control on the output voltage (Q5, R11,C11,D8), giving increased stability. However, the lowest voltage is about 1.35v, while in the previous design (schematic 1) the voltage can by zero.
When problems with spikes or irregular voltage control then try to disconnect Q5 and take it from there.

Special thanks to *Andrew B.* concerning the feedback of the output voltage.

Less maximum output voltage needed?
In operation, the LM317 develops a nominal 1.25V reference voltage, VREF, between the output and adjustment terminal.
The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I1 then flows through the output set resistor R2, giving an
output voltage of



Since the 100 uA current from the adjustment terminal represents an error term, the LM317 was designed to minimize IADJ and make it very constant with line and load changes.
To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

More of my projects: 78h05_powersupply

This is how Ivan Lops made it:



click to enlarge
Many thanks Ivan!!

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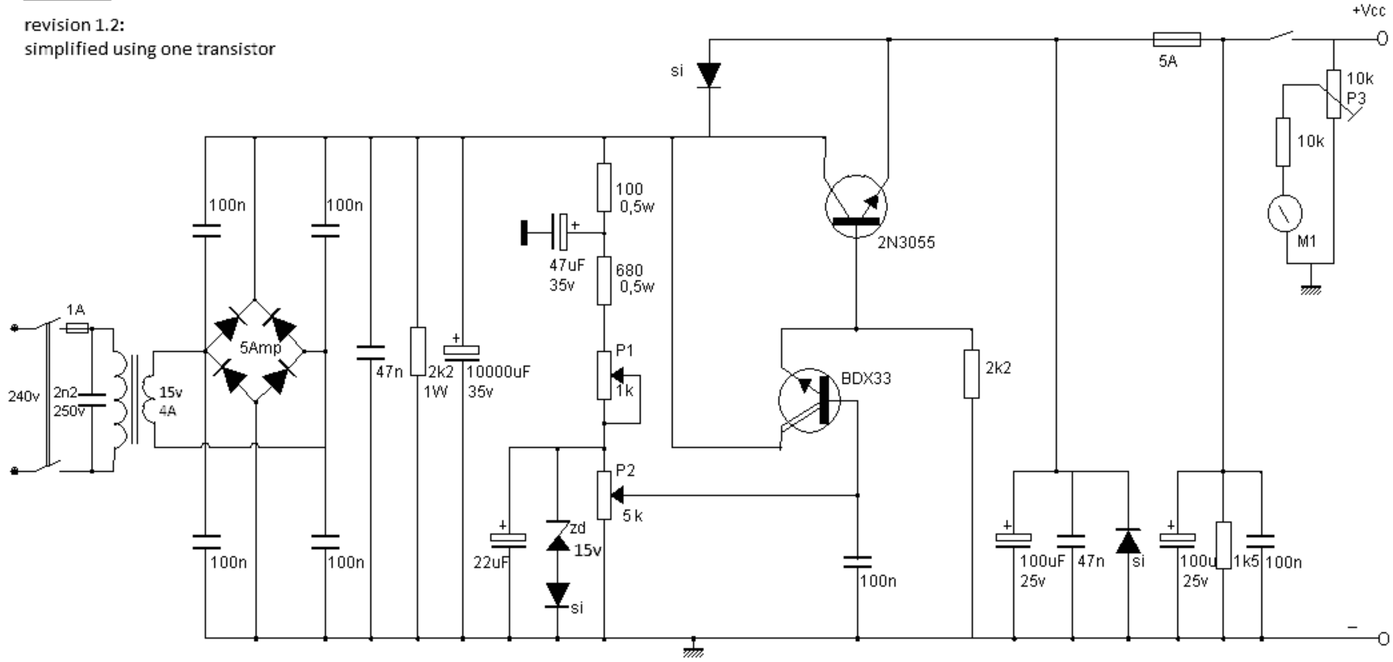
4 ampere regulatable power supply 1...15volt RE-PSR4A18

RE-PSR4A18 4 AMP regulated powersupply.

de ON6MU

revision 1.2:
simplified using one transistor



P1 = sets maximum current (if do not need to be able to decrease amperage, remove P1

P2 = regulates output voltage between 0 and 15v DC.
P3 = trimmer to calibrate M1 voltage meter.

http://www.qsl.net/on6mu

Revision 2017
Using one transistor and removed coils and serie base resistor. P2 is reduced to 5k.
The powersupply can easily give 4 amps 24/24 and 5amps for an hour or two without any issues (peak 6A).

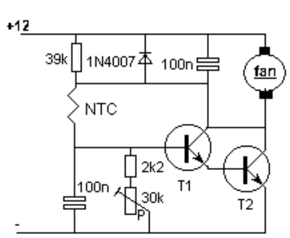
This how Morten LA9DNA build it:

click to enlarge
Thanks Morten!

A simple temperature controled fan:

Temperature controled fan kept simple. de ON6MU



Temperature controled fan

T1 =BC338,BC337
T2 = BD137,BD139... If the fan uses less than 250mA a simple BC338 can be used (often a small CPU fan.)
NTC= +/- 30k (not critical, any NTC between 5...60k works)
P = set temperature when the fan needs to work.
You can also set the fan to rotate slowly constantly as the schematic will kick in when the temps get too high hence letting the fan speed up.

www.qsl.net/on6mu

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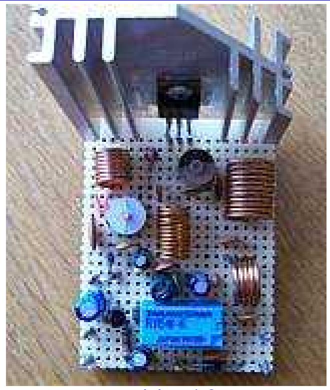
ON6MU

ON6MU

Allmode RF Power Amplifier for the HF 15 and 17 meterband (21Mc/18Mc) RE-PA10HF17 and RE-PA10HF17



revision 1.3

By Guy, de ON6MU

About the 15- and 17-meterband HF amplifiers

This project and your efforts will provide you with a 0.55...3 watt input to easily 10 watt output. The two linear amplifiers are ment for use with QRP SSB/CW/FM/AM transmitters on the amateur bands 15 and 17 meters can be powered from a 12 volt DC supply. The design is a good balance between output power, physical size. The completed amplifier will reward the builder with a clean, more powerful output signal for a QRP rig when radio conditions become marginal. It has a RF-sensing circuit (Q2) wich allows the amplifier to switch on automatically when transmitting. This project uses a "classic" RF transistor. MOSFET power amplifiers are discussed and build in the near future on this website.

Bias
Power amplifiers used in base stations require biasing for proper RF performance. BIAS has be applied to Q1 to have clean proper and correct SSB modulation using this amplifier. Set P1 so +/- 35 mA current flows through Q1. Depending on the type of transistor this can vary somewhat, although you should never exceed 60mA! You don't need SSB? Read next part.

CW/AM/FM only
If you only want to amplify AM/FM/CW/FSK type of modulation (NOT SSB) then you can leave out the BIAS section for Q1 (between b1 and b2 in the schematic). You simply connect connection b2 to the ground, hence leaving out the somewhat critical setting of the correct BIAS for operating clean SSB.

Modulation modes
If using the schematic as displayed below and so also using Q1 BIAS, you can amplify any type of RF generated modulation waves.

Filter
RF purity and harmonic suppression is done here. Also allowing the transistor to be coupled to the antenna system through antenna impedance matching circuitry (C14). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands. This 4-element L-type narrow bandpass filter circuit and a 3 element low-pass PII filter for the desired frequency cleans out any remaining harmonic signals very efficiently.

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.

RF-sensing
The basic principle of RF-sensing using a relay is clearly drawn in the schematic and pretty much self explaining. Q2 (BC338, 2N2222) will conduct when RF energy is applied at the input of the amp (and so also via C18, D3, D5 biasing the base of Q2) hence powering up a RF capable relay. This relay switches between RX and TX with amp. When no Vcc is applied to our amplifier (and so Q2 too) no amplification is done. The input is simply re-directed directly to the output (as if your transceiver is connected without an amp). The RF sensing circuit is sensitive enough to react on .5 watt easily.
To allow the amplifier in SSB-modulation some extended PTT time-on the RF-sensing unit (Q2->relay) has to be increased. This is done by closing S1 (SSB/FM) and so C20 adds the needed "breathing" time. In FM/CW/AM/FSK modes a carrier is present and extended PTT time-on of the amplifier isn't needed, hence can be short.
Important: timing can vary on the type of relay used (Ohms resistance value of the relay coil), so often experimentation of C19 & C20 is needed.

An error in the schematic previous to rev. 1.3 connected the input of the rf-sensing circuit wrongly to C10, instead of the input PL259 connector IN.

Important: Everything will be within specs if you use RY5W relay, but timing (the "breathing time") can vary on the type of relay used (Ohms resistance value of the relay coil), hence experimentation of C31 is needed.

Note:
Although this example of RF-sensing isn't the Worlds most best sollution, it is pretty easy for beginners though. Better would be to drive t2 from your transceiver (amp drive) as this will switch at the very moment of PTT.

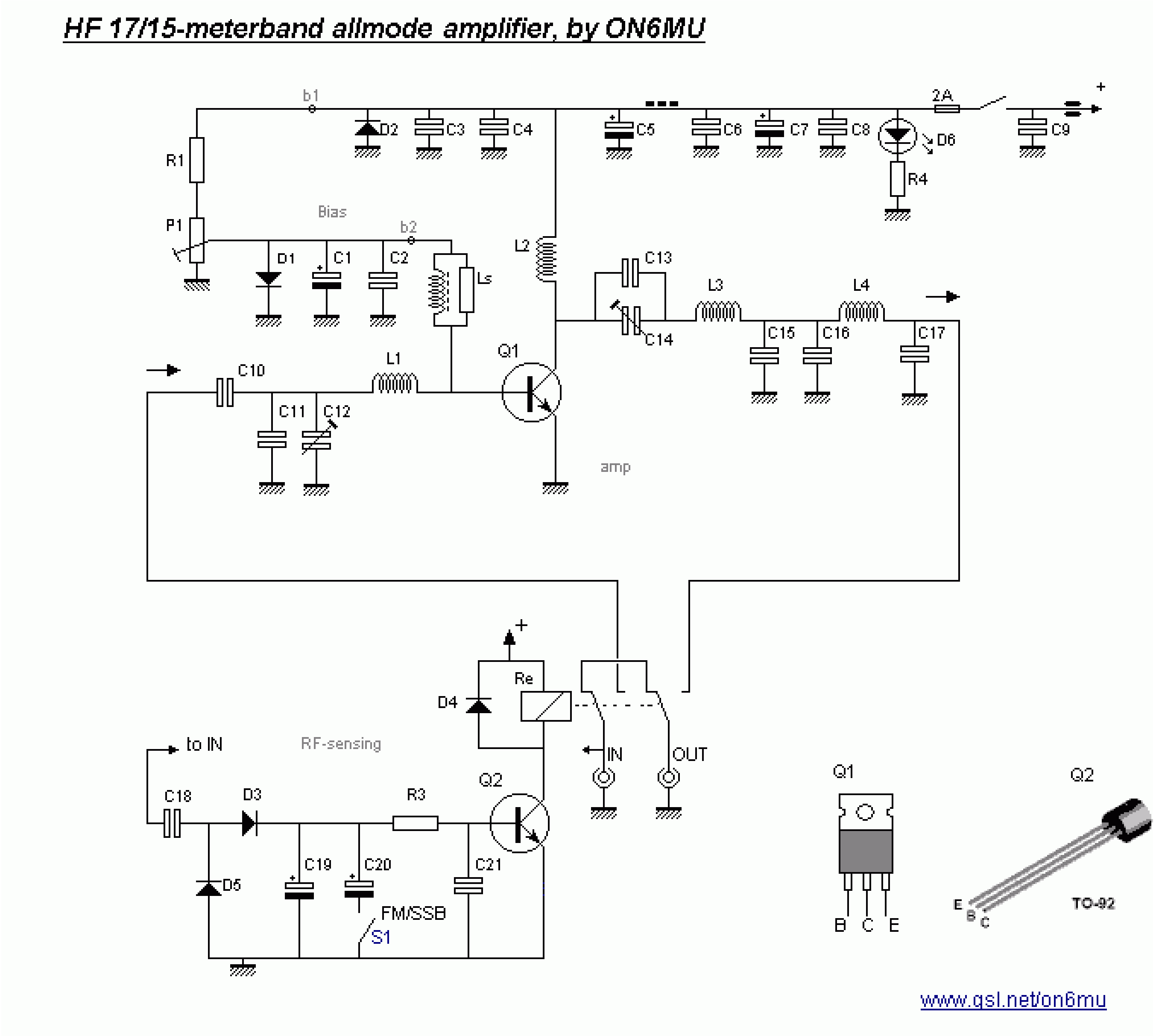
RE-PA10HF17: 17-meterband Amplifier settings

First set C12 and C14 to the middle and centre pin of P1 to the ground. After carefully mounting all parts and using as short as possible connections between the parts, gently add voltage to the amplifier while checking the current. The only current you should see is a the liddle idle current of Q1 (and LED D6 if connected). Increase the voltage to 12 volts. Check current again. It should (at this stage) be lower then +/- 20mA.

Now gently turn P1 till you get approx. 35 mA. Do not forget to mount Q1 on a heat sink isolated electrically from the transistor.

So far so good? Now we check if the (Q2) RF-sensing circuit is working properly. Connect a proper dummy load and a power meter to the output of the amp. Remove any connectors from your power supply and temporary disconnect the collector from the VCC. Connect your transceiver to the input. Be sure you set your tranceiver's power to minimum (never more then 3 watts) and you set your transceiver to 18.100Mc in CW/FM. Key your transceiver and if all goes well the Relay should power up and you should see the current rise and your power meter should already show an amplification of the RF input power.

Still all working as planned? Excellent! Now carefully turn C12 till you get maximum output power (whilest checking the input SWR on your transceiver or SWR meter). And finally tune C14 to maximum power. If needed re-tune C12 and C14 till you reached the maximum. Current should be around 1.2 Amp +/- (depending on the voltage and input power).

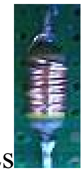


Parts list 17-meterband power amplifier

- Q1 2SC1969 (only Mitsubishi type!!), ERF-2030, 2SC1173, 2SC1944, 2SC2075
  (with proper heatsink isolated from the transistor)
  Note: There are reports I've read on various web sites about counterfeit components especially RF transistors, so be careful in buying huge lots. For example: I know that the 2sc2075 marked with a T works while others not?!
- Q2 BC338, BC337, 2N2222
- C1 1uF/25v
- C2 22nF
- C3 10nF
- C4 560pF
- C5 22uF/25v
- C6 47nF

- C7 100uF/25v
- C8 1nF
- C9 100nF
- C10 68pF
- C11 180pF
  (Stan 9H1LO reported using a 270pF instead of 120pF (rev1.2c 180pF) prevented the amp from oscillating in 24mc, probably do to differences in transistors and PCB)
  (Peter DL6NL reported using a 200pF which allowed 1:1 SWR)
- C12 6...40pF set at half position and tune to max power and best input SWR
- C13 68pF
- C14 6...40pF set at half position and tune to max power on 50 Ohm dummyload
- C15 120pF
- C16 47pF
- C17 180pF
- C18 10pF
- C19 2.2uF/25v
- C20 68uF/25v
- C21 100nF
- R1 1k5 (revision 1.2)
- R3 1k5
- R4 1k
- P1 5k (revision 1.2) pot. to set BIAS for correct SSB operation +/- 35mA@13.8v
- D1 1N4148 (revision 1.2)
- D2 1A si diode 1N4001, 1N4005
- D3,D4,D5 1N4148
- D6 LED
- Re = 12volt relay with silver plated contacts and low RF capacitance with 2times 3pole switch: RY12W-K
- L1 = 1mm Cul (insulated copper wire), 7 turns close together, 7mm inside diameter
- L2 = 0.6mm Cul (insulated copper wire), 14 turns 0.5mm space, 7mm inside diameter
- L3 = 1mm Cul (insulated copper wire), 11 turns close together, 10mm inside diameter
- L4 = 1mm Cul (insulated copper wire), 5 turns close together, 10mm inside diameter

- Ls = 470 1/2 watt carbon, 0,2 Cul turned 3 times over the entire length of the resistor
- Ferrite bead 3 turns wire inside
- S1 switch open = AM/CW/FM/PSK/PKT, switch closed = SSB

Ls 

Note:
Always use a dummy load for testing and adjusting the amplifier!!!

Specifications RE-PA10HF17

- Peak Frequency range: 18Mc...18.5Mc
- Output RF power: at least 8W @ 13.8v - 12W@16v
- All modulation modes
- Adjustable output impedance to 50 Ohms
- Adjustable input impedance to 50 Ohms
- High efficient band-pass type harmonic L-filter + lowpass PII filter
- PII-filter at input
- Usable voltages: Vcc 10 - 18 volts
- Average current I: +/- 1A @ 14 v
- RF-sensing
- VSWR overload resistant (not infinite)
- Can be used without complex BIAS if only needed for CW/AM/FM/FSK type modulation

How **Peter DL6NL** made it!
Click image to enlarge

RF Power transistors:

2SC1969/ERF-2030

Features:

- High Power Gain: G_{pe} >/= 12dB (V_{CC} = 12V, P_O = 16W, f = 27MHz)
- Ability to Withstand Infinite VSWR Load when Operated at:
  V_{CC} = 16V, P_O = 20W, f = 27MHz

Application:

- 10 to 14 Watt Output Power Class AB Amplifier Applications in HF Band

Absolute Maximum Ratings: (T_C = +25°C unless otherwise specified)

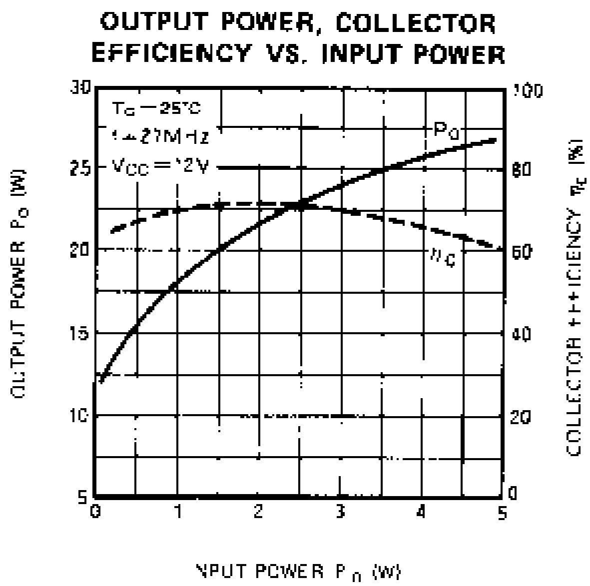
Collector-Emitter Voltage (R_{BE} = Infinity), V_{CEO}	25V
Collector-Base Voltage, V_{CBO}	60V
Emitter-Base Voltage, V_{EBO}	5V
Collector Current, I_C	6A
Collector Power Dissipation (T_A = +25°C), P_D	1.7W
Collector Power Dissipation (T_C = +50°C), P_D	20W
Operating Junction Temperature, T_J	+150°C
Storage Temperature Range, T_{stg}	-55° to +150°C
Thermal Resistance, Junction-to-Case, R_{thJC}	6.25°C/W
Thermal Resistance, Junction-to-Ambient, R_{thJA}	73.5°C/W

Electrical Characteristics: (T_C = +25°C unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 1mA, I_E = 0	60	-	-	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 10mA, R_{BE} = Infinity	25	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 5mA, I_C = 0	5	-	-	V
Collector Cutoff Current	I_{CBO}	V_{CB} = 30V I_E = 0	-	-	100	µA
Emitter Cutoff Current	I_{EBO}	V_{EB} = 4V, I_C = 0	-	-	100	µA
DC Forward Current Gain	h_{FE}	V_{CE} = 12V, I_C = 10mA, Note 1	10	50	180	
Power Output	P_O	V_{CC} = 12V, P_{in} = 1W, f = 27MHz	16	18	-	W

Collector Efficiency			60	70	-	%

Note 1. Pulse test: Pulse Width = 150µs, Duty Cycle = 5%.



ERF-2030 Features...

1/ The ERF-2030 is a 25 watt* transistor - therefore, it is not just a replacement part, but also an UPGRADE to the old Mitsubishi part.

2/ The ERF-2030 is NOT an "electrical drop in replacement" for the 2SC2166, 2SC1969 and 2SC2312. However, circuit modifications on most radio's are minimal and documentation is readily available for FREE.

3/The ERF-2030 is a "mechanical drop in replacement" for the 2SC2166, 2SC1969 and 2SC2312. This means that the The ERF-2030 features a TO-220 package with the SAME pinout configuration as the 2SC2166, 2SC1969 and 2SC2312. Therefore NO mechanical modifications to the ERF-2030 are necessary for most installations

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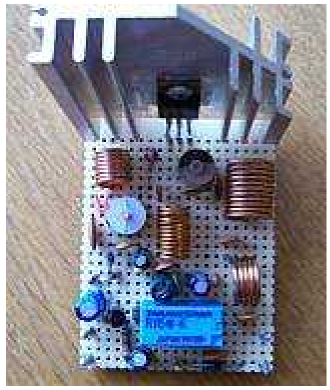
[Allmode RF Power Amplifier for the 15 meterband (21Mc)
RE-PA10HF15]



By Guy, de ON6MU

About the 15-meter band HF amplifier RE-PA10HF15

All is already explained above (17-meter band amplifier): Read it here

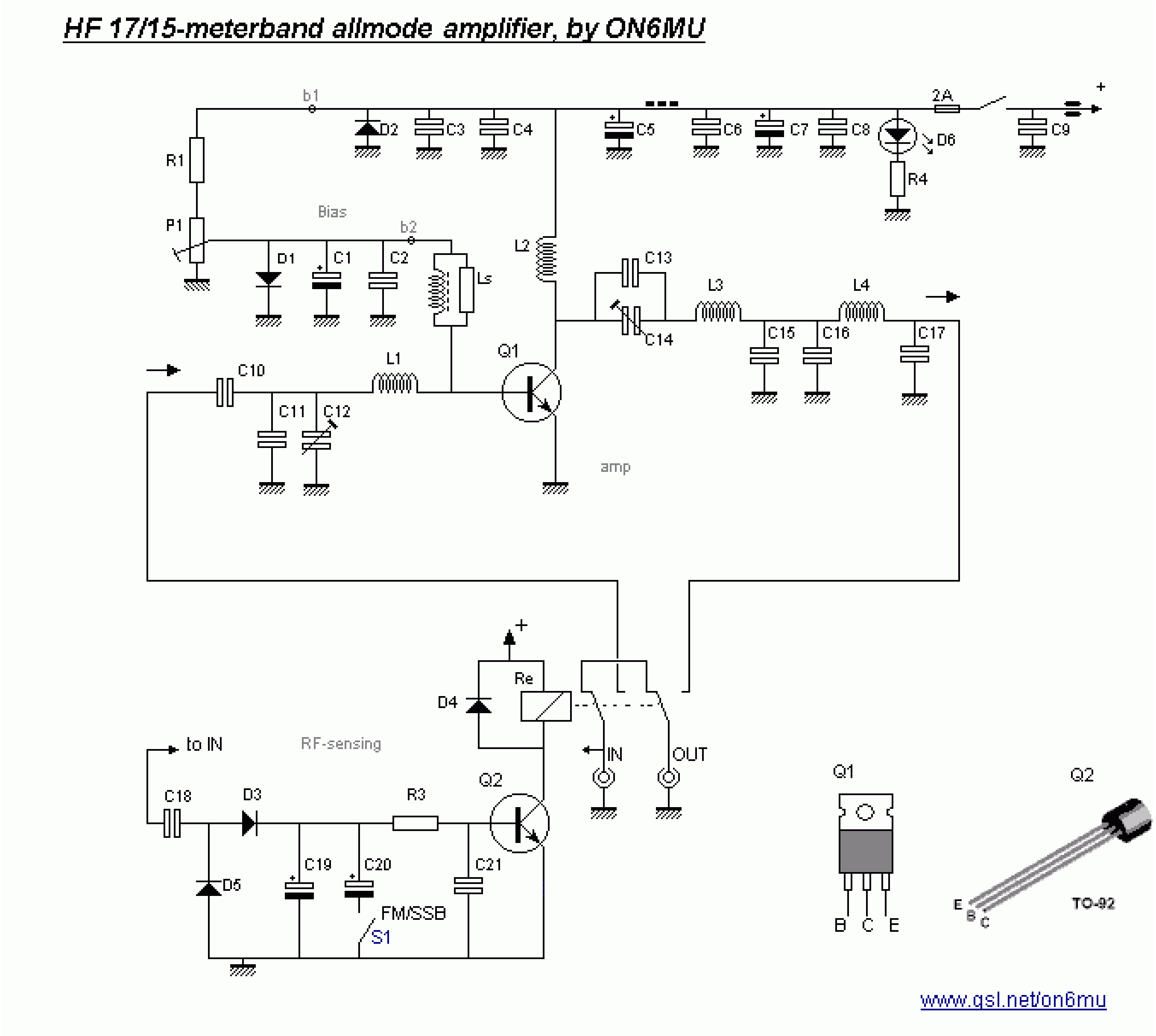
15-meterband Amplifier settings

First set C12 and C14 to the middle and centre pin of P1 to the ground. After carefully mounting all parts and using as short as possible connections between the parts, gently add voltage to the amplifier while checking the current. The only current you should see is a the liddle idle current of Q1 (and LED D6 if connected). Increase the voltage to 12 volts. Check current again. It should (at this stage) be lower then +/- 20mA.

Now gently turn P1 till you get approx. 35 mA. Do not forget to mount Q1 on a heat sink isolated but electrically from the transistor.

So far so good? Now we check if the RF-sensing circuit is working properly. Connect a proper dummy load and a power meter to the output of the amp. Remove any connectors from your power supply and temporary disconnect the collector from the VCC. Connect your transceiver to the input. Be sure you set your tranceiver's power to minimum (never more then 3 watts) and you set your transceiver to 21.200Mc in CW/FM. Key your transceiver and if all goes well the Relay should power up and you should see the current rise and your power meter should already show an amplification of the RF input power.

Still all working as planned? Excellent! Now carefully turn C12 till you get maximum output power (whilest checking the input SWR on your transceiver or SWR meter). And finally tune C14 to maximum power. If needed re-tune C12 and C14 till you reached the maximum. Current should be around 1.2 Amp +/- (depending on the voltage and input power).

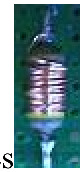


Parts list 15-meterband power amplifier RE-PA10HF15

- Q1 2SC1969 (only Mitsubishi type!!), 2SC1173, 2SC1944
  (with proper heatsink isolated from the transistor)
- Q2 BC338, 2N2222
- C1 1uF/25v
- C2 22nF
- C3 10nF
- C4 560pF
- C5 22uF/25v
- C6 47nF

- C7 100uF/25v
- C8 1nF
- C9 100nF
- C10 68pF
- C11 100pF *(If amp oscillates in higher frequencies do to transistor deviations or PCB coupling, try 180pF)*
- C12 6...40pF set at half position and tune to max power and best input SWR
- C13 56pF
- C14 6...40pF set at half position and tune to max power on 50 Ohm dummyload
- C15 100pF
- C16 47pF
- C17 150pF
- C18 8pF
- C19 2.2uF/25v
- C20 68uF/25v
- C21 100nF
- R1 1k5 (revision 1.2)
- R3 1k5
- R4 1k
- P1 5k (revision 1.2) pot. to set BIAS for correct SSB operation +/- 35mA@13.8v
- D1 1N4148 (revision 1.2)
- D2 1A si diode 1N4001, 1N4005
- D3,D4,D5 1N4148
- D6 LED
- Re = 12volt relay with silver plated contacts and low RF capacitance with 2times 3pole switch: RY12W-K
- L1 = 1mm Cul (insulated copper wire), 6.5 turns close together, 7mm inside diameter
- L2 = 0.6mm Cul (insulated copper wire), 12 turns 0.5mm space, 7mm inside diameter
- L3 = 1mm Cul (insulated copper wire), 11 turns close together, 10mm inside diameter
- L4 = 1mm Cul (insulated copper wire), 4.5 turns close together, 10mm inside diameter
- Ls = 470 1/2 watt carbon, 0,2 Cul turned 3 times over the entire length of the resistor

- Ferrite bead 3 turns wire inside
- S1 switch open = AM/CW/FM/PSK/PKT, switch closed = SSB

Ls 

Note:
Always use a dummy load for testing and adjusting the amplifier!!!

Specifications

- Peak Frequency range: 21Mc...21.5Mc
- Output RF power: at least 8W @ 13.8v - 12W@16v
- All modulation modes
- Adjustable output impedance to 50 Ohms
- Adjustable input impedance to 50 Ohms
- High efficient band-pass type harmonic L-filter + lowpass PII filter
- PII-filter at input
- Usable voltages: Vcc 10 - 18 volts
- Average current I: +/- 1A @ 14 v
- RF-sensing
- VSWR overload resistant (not infinite)
- Can be used without complex BIAS if only needed for CW/AM/FM/FSK type modulation

Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...). Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your antenna is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is equally important to be able to make DX QSO's.

Related

Remember that transmitting and/or using an power levels higher then your local license permit is illegal without a valid radioamateur license!

Another related project:1watt 10 meterband transmitter project

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Magnetic longwire baluns 1:9

combined with ground, a 1:4 and 1:1 balun connections

RE-ABU1HF

By Guy, de ON6MU

About the MLB (magnetic longwire balun RE-ABU1HF)

This Magnetic Longwire Balun (MLB) makes it possible to efficiently use a coaxial lead-in cable with all forms of longwires, T-forms or other types of wire antennas, without the need for an antenna tuner. A very low loss magnetic transfer of energy from the antenna to the receiver is accomplished and static noise is reduced. Your coax is much less susceptible to interference. You can even connect a dipole to it.
It works fine with a heavy duty 41 foot (12.5 meters) wire, some nylon rope and a quality insulator. At the feed-line end the antenna is terminated with the Magnetic Longwire Balun. This balun permits an exceptionally low loss transference of antenna energy to your coax feed line. The result is significantly reduced static noise on long, medium wave and the shortwave bands.

You do not have to Earth/Ground the Green wire sticking out of the top, but it helps minimize interference if you do. Grounding the balun / coax (pin 3) to a good earth made between 3 and 6 dB improvement on noise and QRM, even though the station was well-grounded.
The key to getting good noise rejection from coax used to feed a longwire is grounding the coax shield well. It makes little sense to extend the coax beyond the farthest ground point from your receiver, since beyond that last ground point the coax would pick up signal anyway, despite its shielding. Thus, a low noise coax-fed longwire will typically fall within the spectrum ranging from verticals through tilted wires and inverted L's to Beverages (long, low, horizontal wires). This balun can smooth out the wild efficiency swings and also give static electricity a path to ground.

You could add a shoke inside (or outside) the balun housing to prevent even more from coax radiating too. A few feritte beads over the coax or turn a piece of 50 coax a few time around a feritte core. If possible inclose the shoke inside the balun housing or as close as possible to the SO239 connector.
Long-wire antennas are directional, so bend yours to allow both N-S and E-W orientation. Height is dependent on your location and surrounds … experiment!!

Pin 1 = 1:9 ratio for longwire (6...100m wire)

Between Pin 2 and Pin 3 = 1:4 balun

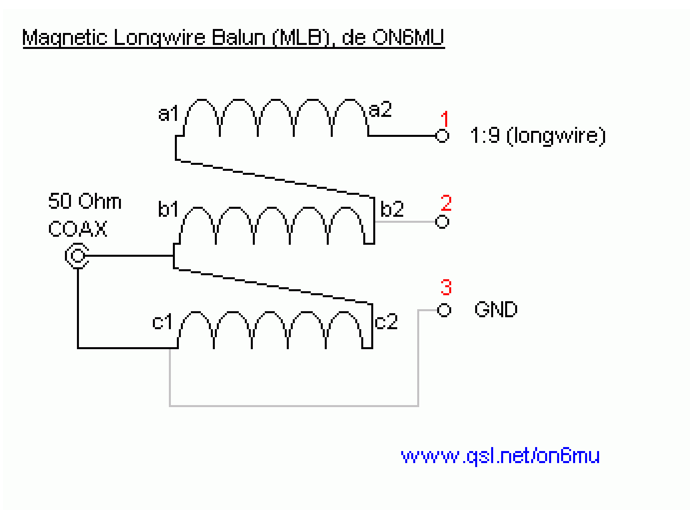
Between Pin 1 and pin 2 = 1:1 balun (dipoles)

You can use one of the bolts to mount your balun too.

If you do have an unknow toroidal core you would like to use, and you do not have the proper equipment to test it, there is a little experiment that can give you at least an indication of the frequency range of the core. So If you want to use other toroidal cores you will have to experiment with the number of windings and test it with a SWR/power-meter, field strength meter and a 450 ohm 1 watt carbon resistor (470 + 10k parallel) soldered between pin 1 and pin 3 (gnd). One SWR/power meter is connected directly to the coax output SO239 and with a field strength meter measure the radiated power at the resistor and check the SWR. Connect your transceiver and test on all bands (@ 0.5 watt).

Second method is using two SWR/power meters and a 50..70 Ohm dummy load. Connect the output of the SWR/Power meter on a dummy load and the output of the meter between pin 1 and pin 2. The second SWR/power meter is connected with a coax to the SO239 of the balun and your transceiver. Check input and output power and the SWR while transmitting on all bands (at low power!). You should see a power drop measured at the balun at non supported frequencies of the core. SWR reading can vary too as the frequency range of the core is lower or higher then the transmitted frequency.
The more turns you manage the better the bandwidth.
I have found that the lower frequencies If you use an Amidon T130-2 red toroid are not to good. To improve the balun on the lower frequency range (1...4Mc) we need to add as much turns as possible. I managed to put 11 turns of 1mm wire (see picture below) and has a very positive influence on the bandwidth, or I simply had a bad T130-2...

Schematic: Magnetic Longwire balun, with 1:1, 1:4 and 1:9 connections



MLB PVC watertight housing and building tips

 50 mm PVC tubes with watertight rings 

Can be bought in any DIY store. These PVC pipes are very ridgid, weatherproof and water tight! Plastic thickness is approx 2mm.

 balun connected to SO239 (for PL259 connector)

This where you connect your 50 Ohm coax to. SO239 connecter is sealed inside with glue and painted with graphite spray/paint. After glueing around the edges of the centre pin, paint a few layers of graphite over the connector and inside the ring which will ensure a good ground contact, prevent corrosion and further seal up the connector for any tiny openings where water could come in. Be sure not to paint the centre pin!!

 inside the balun housing

First solder the 3 antenna connections of the balun. There are 3 'outside' antenna connections needed. The middle for the connecting the longwire antenna (output nr 1 1:9), yellow left side wire for output nr 2 (1:2/1:1) and the black wire on the right for the ground output nr 3. Use innox, copper or galvanised bolts. Vernish, paint or glue at the inside of the pipe the bolts to seal them up and protect them against any corrosion.

If all is sealed up perfectly it should be watertight submerged under 1 meter water.

Parts list longewire balun

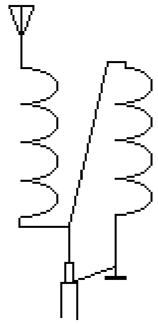
-  feritte core of 30mm, or Amidon T130-2 red or T200-2 red
  
  (or Philips 4C6 or 4C65 (pink color)
- 3 pieces of insulated wire (Cul) of 0,8mm...1mm (The more turns you manage the better the bandwidth. If you want to use other toroidal cores you will have to experiment with the number of windings and test it with an SWR-meter and a 450 ohm resistor (470 + 10k parallel))
- 3 x 30mm 5..6mm diameter weater resistant bolts (innox etc...)
- 50mm diameter PVC pipe (10cm) with two screwable waterproof tops
- SO239 connector

Specifications RE-ABU1HF

- Peak Frequency range: 100kc...30Mc (mostly depending on the core)
- Max. RF power CW: 100W (also depending on the core, the mismatch of the antenna and the transmission intervals)
- Max. RF power SSB: 200W (also depending on the core, the mismatch of the antenna and the transmission intervals)
- Output impedance to 50 Ohms
- 1:9 output for longwire
- 1:1 output for dipole usage
- 1:4 experimental
- protection against electrostatics

Appendix
1:4 Balun
bifilar coil nicely spaced over a red-amidon toroid will do fine

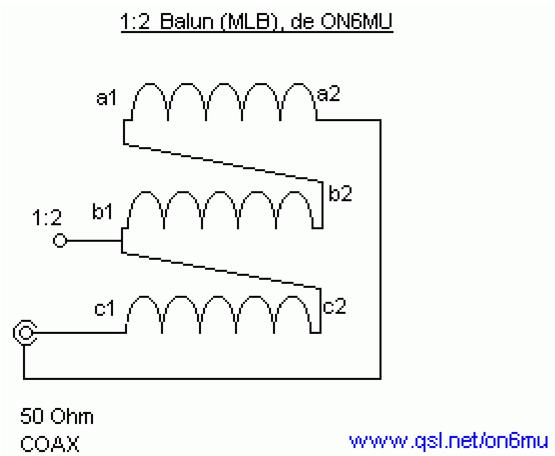
Just to make it complete, and if you just happen to need one, here is the principle schematic for a 1:4 balun only:



bifilar coil nicely spaced over a red-amidon toroid will do fine.

1:2 balun

And here is a 1:2 balun:



trifilar coil nicely spaced over a red-amidon toroid will do fine

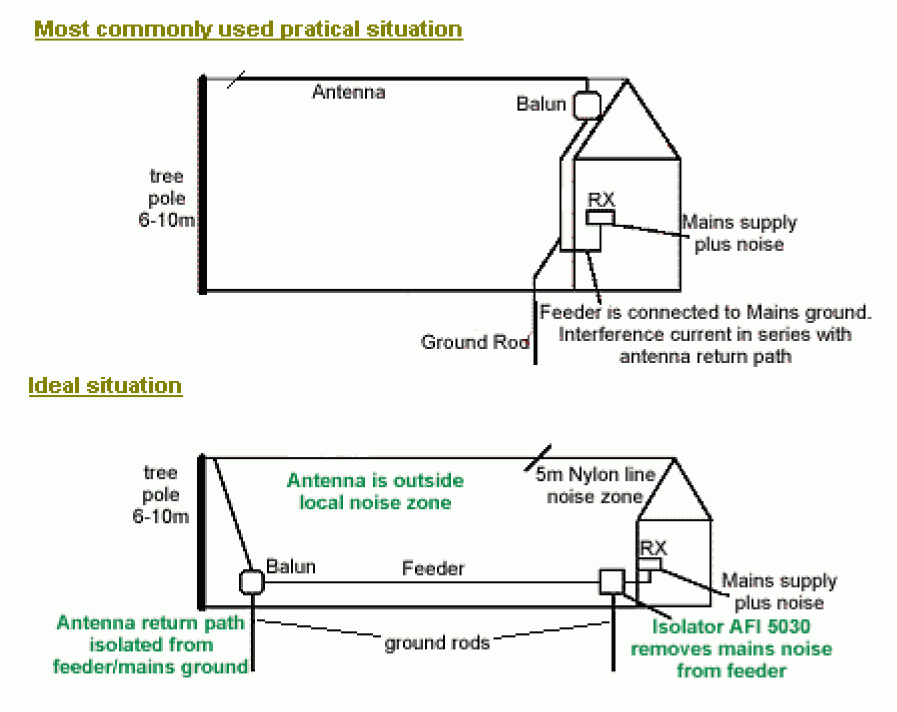
Picture of my handy little QRP (low power) /A 1:9 balun

RE-ABU2HF

Same schematic as the 1:9 balun, but without GND and 1:1 / 1:4 output pin. Using a smaller core that fits snugly inside a 30mm PVC filmroll.
A core of 20mm should be fine up to approx. 20watt FM (40watt SSB), like the FT68-2 or FT80-2
Calculating the power dissiaption of the core: P = U2 / (Q . XL)

After testing glue the top part.
Seal everything.
For QRP or SWL purposes only you can use a Amidon FT50-2, FT50-43 or a T50-7
click here for details

Examples

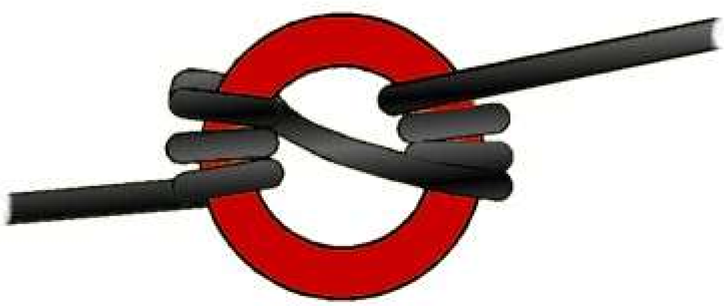


RF Choke to prevent hf currents on the feedline (or...1:1 Choke Balun, sometimes called the "UGLY BALUN")

Ferrite beads hence chokes are used (in a way similar to inductors) as a passive low-pass filter. The geometry and electromagnetic properties of coiled wire over the ferrite bead result in a high impedance (resistance) for high-frequency signals, attenuating high frequency EMI/RFI electronic noise. The absorbed energy is converted to heat and dissipated by the ferrite, but only in extreme cases will the heat be noticeable.

Ferrite beads or coax turned over a ferrite bar are one of the simplest and least expensive types of interference filters to install on preexisting electronic cabling. For a simple ferrite ring, the wire is simply wrapped around the core through the center typically 5 or 7 times. Clamp-on cores are also available, which can be attached without wrapping the wire at all.

However, here we are using a toroid. Just turn 4 times on each side and opposite of each side a piece of RG-58 coax, like this:



 how it looks on an amidon red toroid


HF Choke finished

Choke coils are useful in a wide range of prevention of electromagnetic interference (EMI) and radio frequency interference (RFI) from power supply lines and such. Also prevents TVI from radiating feedlines.
You can add this to your longwire balun, antenna, or whatever needs preventing RF currents from the coax feedline...
Some use it as a 1:1 choke balun, called the "ugly balun".

Tip: use this choke after a longwire balun described above, or build it in the same container.

Another related project: Magnetic longwire balun and VHF-splitter

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Home

Homemade magnetic longwire balun (MLB) for radioamateurs, shortwave listeners (SWL's). Connect your antenna with this schematic to your receiver and transmit, receive,HF. home made

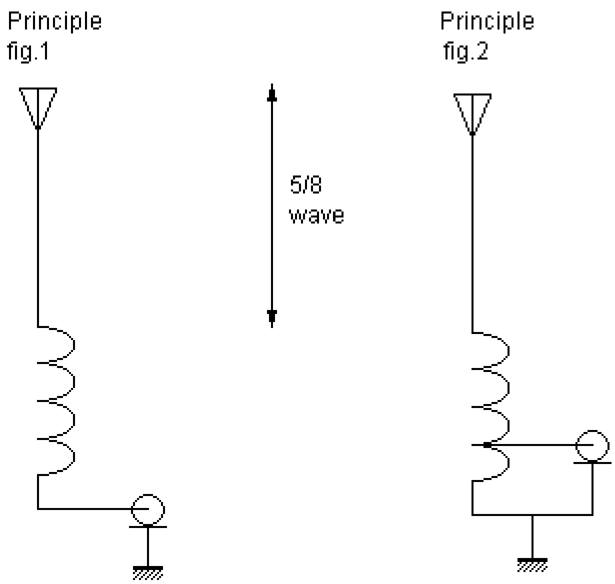
 Electrical Diagram How to Build RF Antenna Design

ON6MU

VHF 5/8wave vertical antennas
RE-A144V58/1

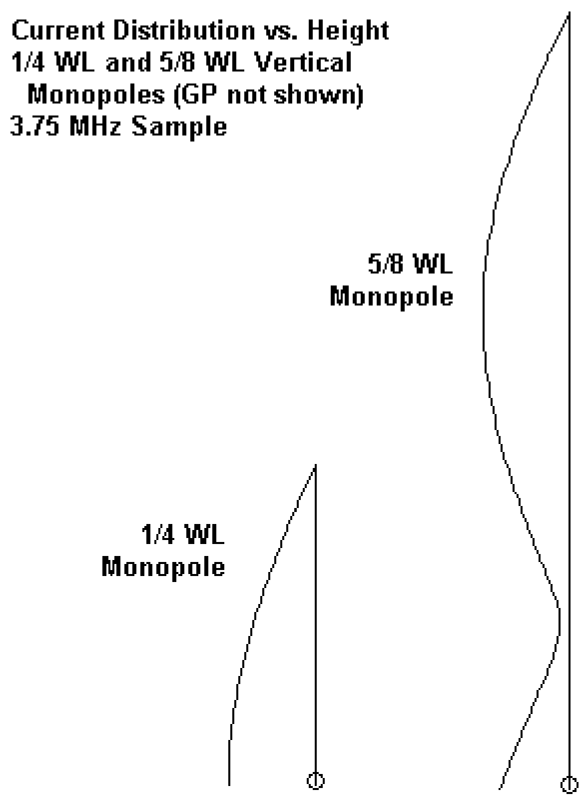
By Guy, de ON6MU

Schematic fig1



The 5/8-wave antenna

At VHF, both the 1/4-wavelength monopole and the 5/8-wavelength monopole antennas are widely used. The VHF 5/8-wavelength (144 Mhz) vertical monopole has long held the reputation of providing about a 3-dB gain advantage over the 1/4-wavelength vertical monopole. The foundation of that reputation rests upon theoretical calculations that show the longer monopole to have the derived gain increase when both monopoles are set over a perfect ground.
A second factor contributing to the reputation of the longer monopole for higher gain is the current distribution along the element. Next Fig shows the distribution for both the long and short monopoles, with the ground plane elements omitted for clarity. The 1/4-wavelength antenna presents its "half-dipole" current distribution curve, while the 5/8-wavelength antenna provides a "half-EDZ" distribution curve. The peak current at a position well above the top of the short antenna is said to give the longer monopole a lower-angle of radiation and additional gain.
The third reason you may want to use the 5/8 wave vertical is to obtain a lower angle of radiation.
Dissadvantage: needs a matching device at the base to match it to the coax, it cannot be attached directly. This antenna has about 1.2 db gain over the dipole antenna and 1/2 vertical.



Parts list

- Type 1:
- alu or copper tubing of 1 meter 15mm tube and 1 meter 12 mm diameter tube
- 3 times 5 mm alu or copper tube of 22 cm
- 1 female PL 259 chassis
- some silver wire of 1 mm
- A robust PVC box of approx 30x50x18 mm and 1,5mm or more thick
- a piece of hard insulating material that snuggly fits inside the base tube, like:
  fiberglass, nylon, hard pvc, hard wood, bamboo etc... as long as it's very strong, stress and

weather resistant.

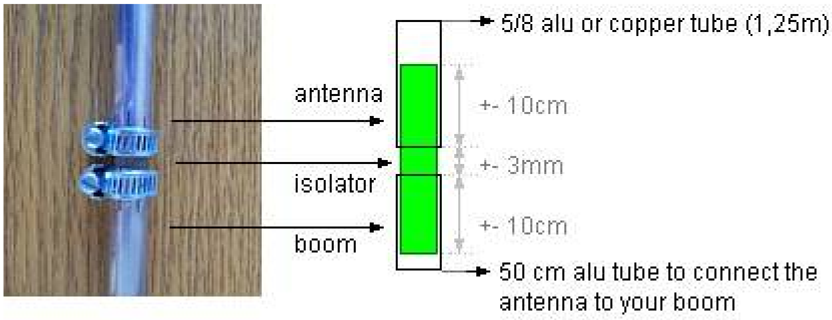
- and a few innox hose clamps
- Type 2:
- alu or copper tubing of 1 meter 15mm tube and 1 meter 12 mm diameter tube
- 3 times 5 mm alu or copper tube of 22 cm
- +- 30 cm 2,5mm electrical installation wire
- a piece of hard insulating material that snuggly fits inside the base tube, like:
  fyberglass, nylon, hard pvc, hard wood, bamboo etc... as long as it's very strong, stress and weather resistant.
- some 50 ohm coax
- and a few innox hose clamps

Note: there are many ways to build your antenna and I'm sure some can come up with better mechanical designs then described here although the design and material used here is cheap and easy to find.
Both types of 144 Mhz 5/8 wave antenna's described here has the same radiationpattern and gain, but type 2 has the advantage of being electrical (and DC) grounded and can disipate more power.

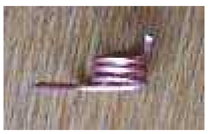
The antenna type 1
RE-A144V58/1

- The antenna:

  - saw the 1 meter 15 mm alu tube in half. One part (50 cm) will be used as a boom and the other as the first part (also 50cm) of the antenna.
  - saw some grooves (approx 1,5 cm) in the both halves of the tube to allow a hose clamp to tighten everything up.
  - the 1 meter 12 mm alu tube is fitted inside the 15 mm base tube and can be hold tight with a hose clamp. Measure from the base up 1,3 meters. You can alwyas tune the antenna to its best SWR by sliding the top tube in or out.



- saw a piece of that hard insulating material of your choice and fit it 10 cm in the antenna and boom part and leave a gap of 3 mm between them.
- hammer down one end of each of the 3 radials (3 x 22 cm) so it becomes a bit flatten. This will make things easier to screw tight with the hose clamp. These radials are fitted on the boom section.

- The coil:
  
  Wind 3,2 turns of silver plated copper wire of 1mm thickness with an inside coil diameter of 8 mm (outside 10mm) and a the coil has a little spacing of approx. 0,2 mm.

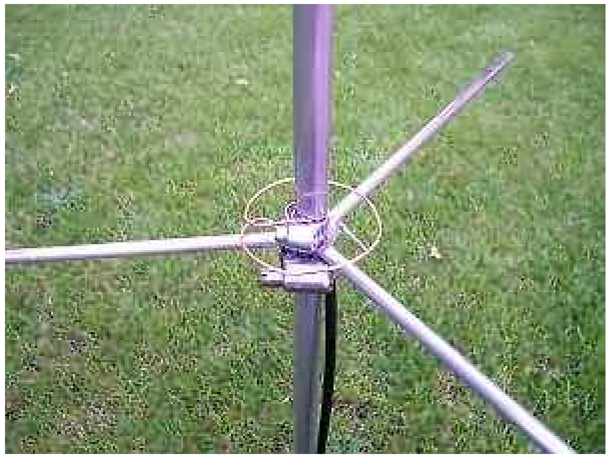
- Connect the coil to the antenna and the other end to the centre of your 50 ohm coax cable.
  I used a little plastic box where I placed the coil and the PL connector.

-

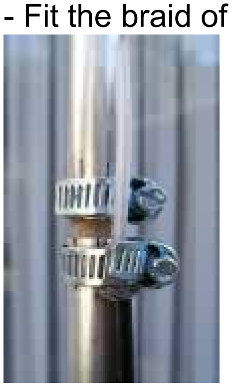
[Specifications antenna type 1
RE-A144V58/1]

- centre frequency: 145 Mhz
- bandwidth: 2 Mhz
- maximum tunable frequency range: 142...150 MHz +-
- impedance: 50 Ohms
- Gain: 4,1 dBi
- maximum power using described components: 150watt +-
- heigth: 1,25 m

[The antenna type 2
RE-A144V58/2]



- The antenna:
  - saw the 1 meter 15 mm alu tube in half. One part (50 cm) will be used as a boom and the other as the first part (also 50cm) of the antenna.
  - saw some grooves (approx 1,5 cm) in the both halves of the tube to allow a hose clamp to tighten everything up.
  - the 1 meter 12 mm alu tube is fitted inside the 15 mm base tube and can be hold tight with a hose clamp. Measure from the base up 1,3 meters. You can alwyas tune the antenna to its best SWR by sliding the top tube in or out.
  - saw a piece of that hard insulating material of your choice and fit it 10 cm in the antenna and boom part and leave a gap of 3 mm between them.
  - hammer down one end of each of the 3 radials (3 x 22 cm) so it becomes a bit flatten. This will make things easier to screw tight with the hose clamp. These radials are fitted on the boom section.

- - Fit the braid of the 50 ohm coax to the boom section
  

- The "ringostar" based coil:
  Is made out of 26 cm of 2,5mm installation wire. Remove the isolation of the wire and tin with a soldering iron the entire wire. The coil is 1,2 turns and has a diameter of 5 cm. One side is connected to the antenna and the other side to the boom.

- Find the 1:1 SWR position of the connection the centre of your coax should be soldered to. Half way the coil is a good place to start. Be sure your antenna length is measured up to 1,25 m. When you found the "sweat" spot solder the the centre to the coil. You can alwys fine tune the

antenna for best SWR by sliding in or out the top tube of the antenna.

[Specifications antenna type 2
RE-A144V58/2]

- centre frequency: 145 Mhz
- bandwidth: 2 Mhz
- maximum tunable frequency range: 143...149 MHz +-
- impedance: 50 Ohms
- Gain: 4,2 dBi
- DC grounded (no static buildup)
- maximum power using described components: 250watt +-
- Height: 1,25 m

Be sure to seal everything up to avoid moisture, corrosion etc...

ON6MU
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RF Power meter / dummy load

By Guy, de ON6MU

rev1.2

About the power meter / dummy load

A 50 Ohm dummyload is an essential part for any radioamateur as is a powermeter. The prices of such relative simple equipment is expensive, but not for us handy Hams HI. All you need is a metal box (or plastic box painted inside with graphite or other conducting/RF-shielding capable material), a few resistors and basic components (which can be salvaged from old radio's, switching power supplies etc..) and a analog meter. I used a Radio-shack meter, but any (sensitive) meter can be used. It's all a matter of calibrating your meter correctly, which is easy if you can lend a good commercial RF power meter.

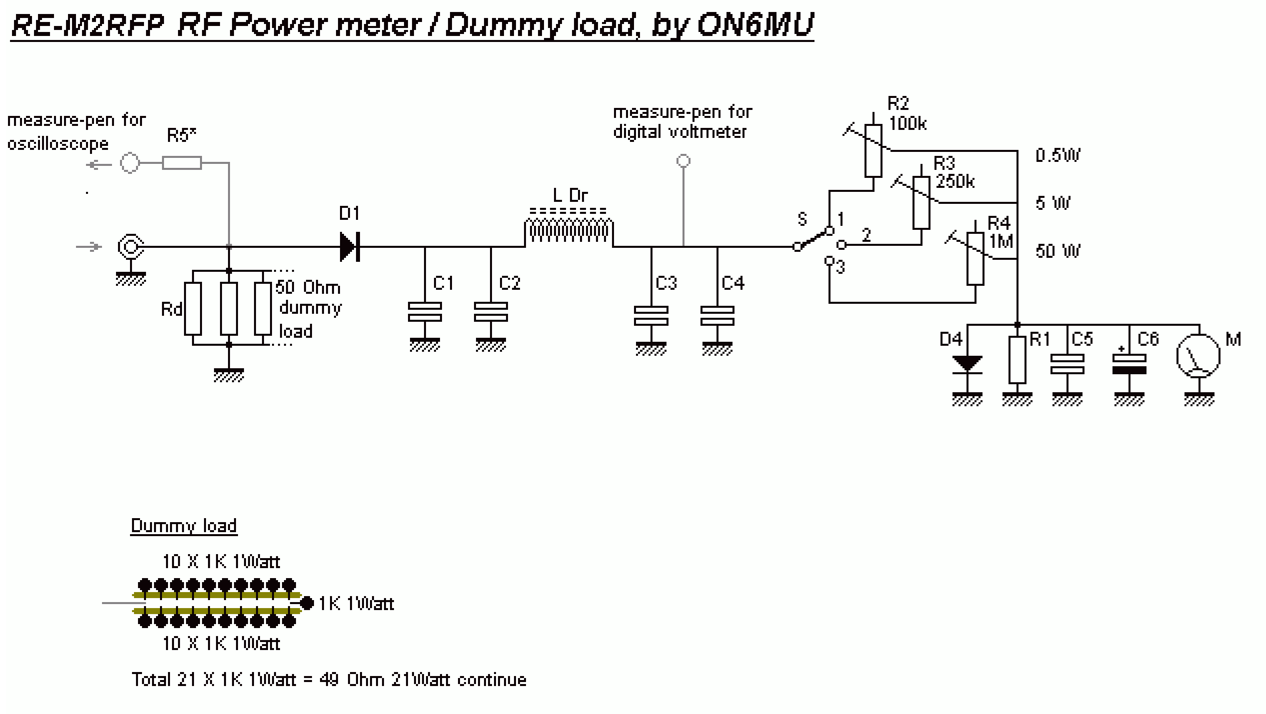
This RF-power meter combined with build-in dummy load is made to measure power levels starting from a few milliwatt up to 50 watts (or more if suitable components are used and an avalanche sinterglass diode). IT has 3 scale readings: 0.5 watt, 5 watt and 50 watts. Again, you can extend the scales easily. The power meter is ideal for measuring QRP levels and by adding a connector you'll have an easy oscilloscope measuring point.

In short, an easy and cheap project to build yourself. Even a beginner in HAM homebrewing can make his own fair (if not better then most you buy in the shop) power meter!

Calibration

Is done with a good (commercial or already calibrated) SWR/RF power meter capable of measuring HF power levels from 5 (or less) to 50 watts and has a frequency range that covers the entire HF-band. You also need a transceiver which you set in series with the meter: TRX -> COMMERCIAL RF METER -> ON6MU RF METER. Set all potentiometers (R2,R3,R4) to maximum resistance. Choose one of the scales (0.5, 5 or 50 watts) to start with. Other power levels/scales with the same step (X1 X10 X100) will have the same indication multiplied. So if you choose scale 2 being 5 watt and calibrate at least 5 power levels of your transceiver it should be ok for the other scale selections. Set R3 for full scale at 5 watt and work your way down. One calibration for all power level settings respectively is sufficient.

Schematic fig1



Parts list

- alu box (or plastic box painted inside with graphite) of 100mm X 100mm X 50mm
- 1 female PL 259 chassis (SO239)
- 1 connector to be used as oscilloscope measuring point
- Analog Meter (as sensitive as possible and calibrate the scale with a good powermeter)
- C1,C3 = 330pF
- C2,C4 = 47nF high quality
- C5 = 100nF
- C6 = 10uF/6v tantal
- D1,D2 = BYW54...BYW56 (up to 500watt measurements) rev1.2. I used a BYW55 controled avalance rectifier ....= or 1N1448 if you do not need to measure more than 10 watt max
- D4 = 1N1004 (protects the meter for voltages higher then 0.6 volts)
- S1 = 3 pos. switch (or more if you want more power scales)
- L Dr = 500uH or 1M Ohm carbon resistor 1 watt covered with 0,2mm Cul 3 times (or more) turned over the length of the resistor
- R1 = 18k
- R2 = 100k variable resistor
- R3 = 250k variable resistor
- R4 = 1M variable resistor

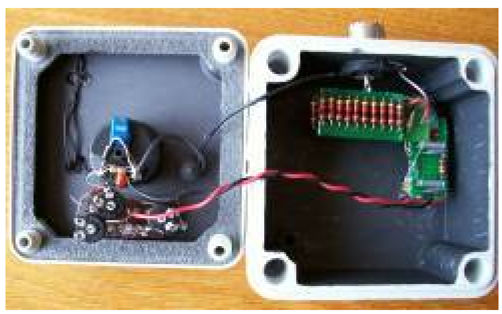
- R5 = 47 (optional; if you add a connector to be used for measuring the RF with an oscilloscope)
- Rd = 50 Ohm Dummy load of at least 20 watt (see text)*

Specifications

- precision power meter capable of measuring power scales of 500mW...100W+ (depending on the dummy load)
- frequency range: entire HF band 1Mc...50Mc
- switchable scale ranges (in this schematic 0.5W, 5W, 50Watts...)
- oscilloscope measuring point
- can be used as dummy load also HI

Note rev1.2*: sometimes the diodes broke when measuring 50watts. To measure power levels up to 100 watts or more a better diode (BYW55) has been used that is suitable for high voltages (Standard Avalanche Sinterglass Diode).

Inside the powermeter



Dummy load

Is build out of 21 carbon resistors (or non inductive metalfilm) of 1K and 1Watt all parallel. I used two 15mm X 50mm print boards and soldered two times 10 resistors on each side. Solder the two parts on top of each other and solder the 21th 1K resistor where the two parts come together. See fig1 and 2. Do not use inductive type of resistors! Always use carbon based resistors or non inductive metalfilm ones. This dummy load is able to dissipate 21 watts continues and no problem to handle a 10 second peek of 50 watts. Long enough to measure the power. Be sure not to transmit high power > 21 watt for a long time as this will burn out your dummy load! IF you need the dummy load to handle more power then you could use 45 2k2 1 watt resistors which doubles the amount of power (and peek power). Of course you can use 1 k resistors of a higher power rating as long as they are non-inductive resistors.

fig.2. 

Don't forget to check these out:

.**ON6MU Homebrew projects**
.Radioamateur related projects

.**ON6MU Ham mods**
.Modifications of transceivers

73"

ON6MU

[Home](http://users.belgacom.net/hamradio/)

ON6MU's

Allmode 5-band RF Power Amplifier

for the HF 80, 40, 30, 20 and 17 meterband

RE-PA30HF5B

By Guy, de ON6MU
rev1.1b oct/09
Prototype

About the 5-band HF amplifier RE-PA30HF5B (prototype)

This project uses a widely available IRF510 MOSFET. This N-Channel enhancement mode silicon gate power field effect transistor is an advanced power MOSFET designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation.
MOSFETs operate very differently from bipolar transistors. MOSFETs are voltage-controlled devices and exhibit a very high input impedance at dc, whereas bipolar transistors are current-controlled devices and have a relatively low input impedance. Biasing a MOSFET for linear operation only requires applying a fixed voltage to its gate via a resistor.
The built-in self-regulating actions prevent MOSFETs from being affected by thermal runaway. MOSFETs do not require negative feedback to suppress low-frequency gain as is often required with bipolar RF transistors.
I chose the IRF510 because lots of hams use 'em and they're cheap. But they perform a bit less when it comes to constant gain and/or power output across a wide range of frequency bands. I wasn't especially concerned with that, and the advantages outweigh the contra's, so I went with that MOSFET.

Rather then using a 1:4 toroid (which is excellent) to match Q1 impedance to 50 Ohms, I have applied the "old school" radio valve coupling; impedance matching circuitry between the output and the antenna using a L-filter...Why? FET devices are more closely related to vacuum tubes than are bipolar transistors (and because I do like to do things my way HI). Both vacuum tubes and the FET are controlled by the voltage level of the input rather then the input current. They have three basic terminals, the gate, the source and the drain. These are related and can be compared to the vacuum tube terminals. The ralationship between the two doesn't stop here...The two most important relationships are called the transconductance and output. An advantage of MOSFET devices is that they do not have gate leakage current and MOSFETs do not need input and reverse transconductance.

The amplifier is made to be driven by transmitters in the ½ to 2 watt range. Built-in to the power amplifier is a sensitive (Q2) T-R relay which will switch the unit in and out of the
antenna line. When in receive, the amplifier is bypassed and the antenna feeds directly to the input jack, when you go to transmit, the T-R circuit detects the transmit RF power and automatically switches the power amplifier into the circuit and amplifies the applied RF power. If you decide to run "barefoot" turning off the AMP it will disable the amplifier and your QRP
transmitter will feed directly through the amplifier without any amplification.
Power is supplied by any 14 to 25 volt (or 2 x 12v battery) DC source with a current draw of 1 to 3 amps depending upon RF power output.

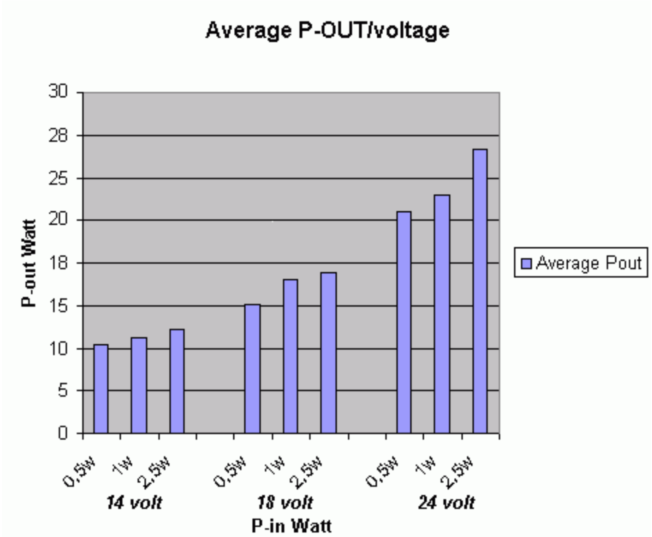
The linear amplifier can be used with QRP SSB/CW/FM/AM/PSK transmitters on any of the amateur bands between 80m...17 meters.

The completed amplifier will reward the builder with a clean, more powerful output signal for a QRP rig when radio conditions become marginal.

Band selection
Switching beween bands is done manually using a rotary switch.
You can build the amplifier for only one band or a combination of any other of the five available bands.

Drive
The input drive can be anything from 0.4watt to 2 watt max, which will be amplified to +/- 25 watt. The output varies on the drive power and the applied voltage.

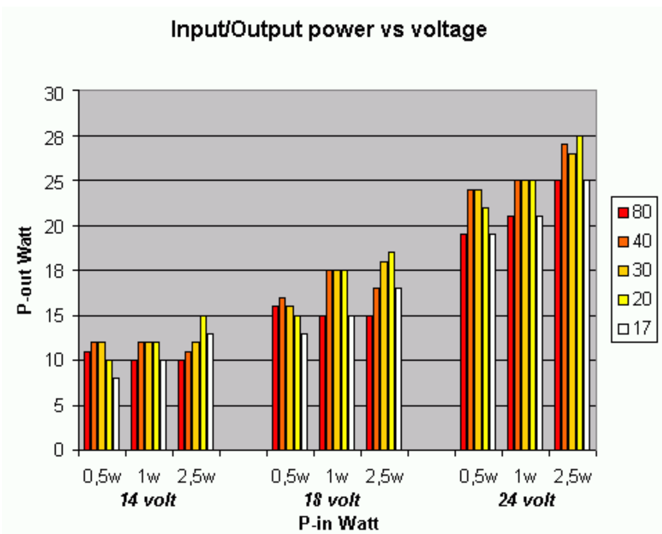
Graph 1: Average Output Power vs voltage



Power
The power output is not perfectly linear to the input frequency/band. The impedance 50 Ohms match could be solved by using a 1:4 toroid, or as I like to use, the "old school" radio valve coupling; impedance matching circuitry between the output and the antenna using a L-filter...And, the IRF510 isn't perfect (*note: there are also low grade versions of the Mosfet out there which can lower the output power and influence the quality of the signal/waveform*).
The N-channel mosfet has an input capacitance thats a bit on the high side and the output capacitance that varies with the cross over frequency. It can be a slight problem when it comes to constant gain and/or power output across a wide range of frequency bands. I wasn't especially concerned with that so I went with this MOSFET anyway. Of course the main issue was the simple design to be able to use one band or even up to five bands if wanted, which always has some compromise in this type of design. This means that there is some fluctuation of the output power par band.

When driven between the optimal range of +/- 1.5 watt the amplifier more then capable to deliver 25 watts +/- 10%. Output power for AM should be set to +/- 50% of max.
Although the design allows you to work in a varied range of voltages, the maximum output is only guarenteed @ 24volts.

Graph 2: Input/Output Power vs Voltage



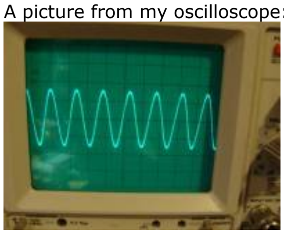
Higher power then 2 watts does not improve linearity as you can see in the above chart.

Bias
The power amplifier require biasing for proper RF performance. BIAS has be applied to Q1 to have clean proper and correct SSB modulation using this amplifier. Set P1 so that +/- 100 mA current flows through Q1.

Modulation modes
If proper BIAS to Q1 is applied, you can amplify any type of modulated wave.
Output power for AM should be set to +/- 50% of max.

Filter
RF purity and harmonic suppression is done here. Also allowing the FET to be coupled to the antenna system through antenna impedance matching circuitry (C16...C20, L2, C21...C25, C26, L4,C27). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band/harmonics on other bands. This 4-element L-type narrow band-pass filter circuit and a 3 element low-pass Butterworth PI filter for the desired frequency removes out any remaining harmonic signals very efficiently.

A picture from my oscilloscope:



RF-sensing
The basic principle of RF-sensing using a relay is clearly drawn in the schematic and pretty much self explaining.
Tip: I would like to recommend to add a mini-switch between C31 and GND if you plan to use it for CW. The on-time is to long for CW.

Input Attenuator
I made provisions to include an RF attenuator consisting out a Pi network of R2, R3/R4, R5 which gives a Forward Attenuation of 3.63 dB and a Input Return Loss of 23.23dB. There are numerous of reasons why I implemented it in this design. It improves overall linearity, achieves some "protection" and enhances stability of the drive input (being a transmitter, transceiver) and Q2 gate.

Cooling/heatsink
Q2 needs to be mounted isolated from the heat sink. Use proper thermal grease and isolator.
I used an old P3 heat sink, which work just fine.


I mounted a Pentium 3 heatsink on the back of the alu-casing. A square space is cut out of the back of the alu-box to allow Q2 to be screwed onto the heatsink. The heatsink is firmly mounted on the back of the chassis with thermal grease allowing the chassis as extra cooling surface.

Construction considerations
HAMs that are experienced in constructing RF projects will know a number of possibilities to create a good RF design.
Because I started from scratch and still was in experimental/design stages I have placed the capacitors/trimmers of each band directly around the switch, including the 80m coil L3. This works perfectly when short connections are used. You can however solder them directly to the PCB.

I mounted a Pentium 3 heatsink on the back of the alu-casing. A square space is cut out of the back of the alu-box to allow Q2 to be screwed onto the heatsink. The heatsink is firmly mounted on the back of the chassis with thermal grease allowing the chassis as extra cooling surface.

One thing I would like to bring to your attention...that are the trimmers that are used to tune each band (Ct1...Ct5). Do not use plastic trimmers, they will melt and perhaps burn through causing shortening and possible failure of Q2 and who knows what else. Please use air- or ceramic based trimmers.
If you do not have them, then the only way tweaking the amplifier by trial-and-error, hence adding C parallel to C16...C20 respectively.
These were my C's: C16=470, C17=340, C18=200, C19=80, C20=43pF

Use a choke (or a snap-on ferrite bead) at the point where the Vcc wires leave the alu-box.

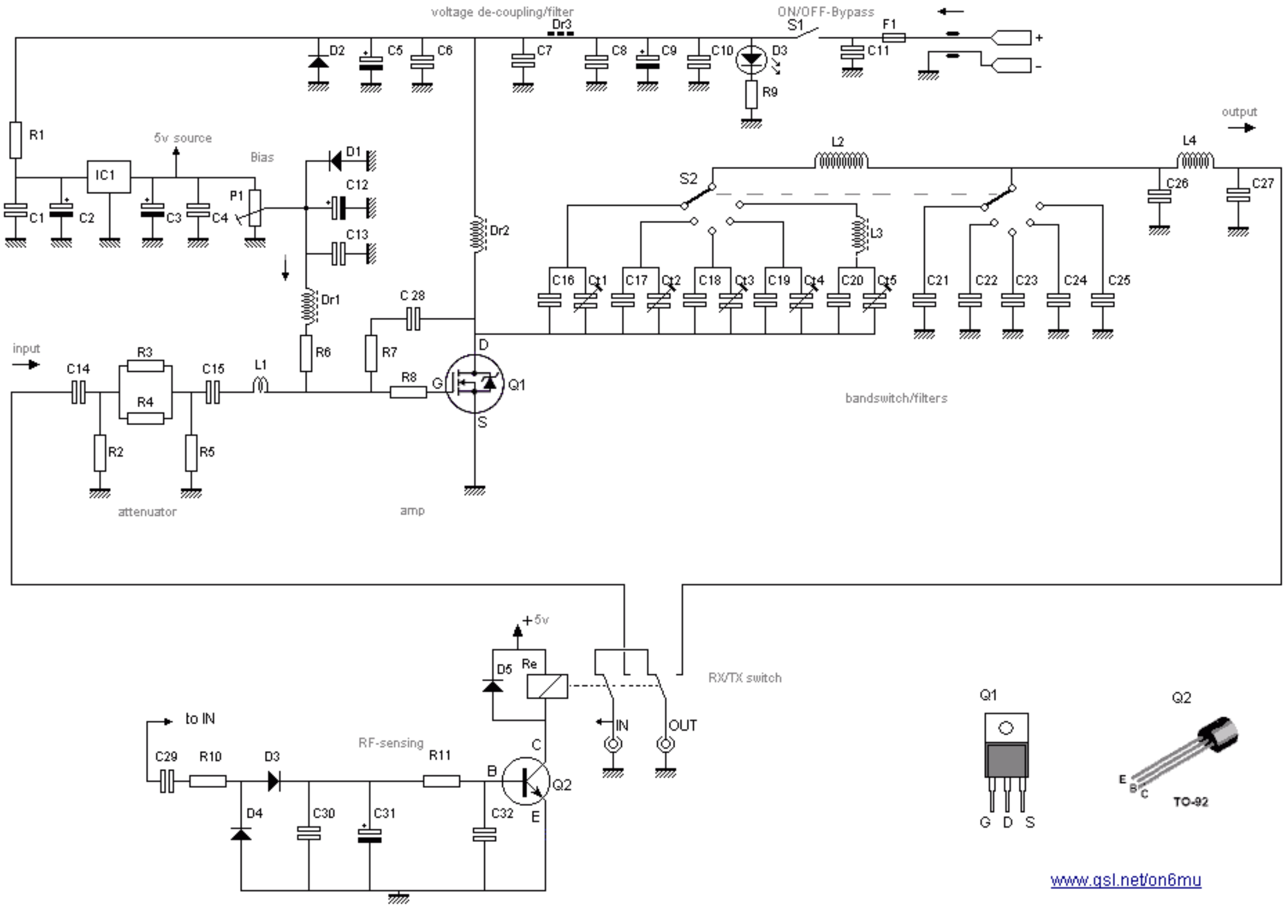
Use small 50 Ohm coax between the in- and output of the PCB connections to the SO-239 connectors.

Enclosure Recommendations
To accomplish RF shielding the whole circuit needs to be mounted in an all-metal/aluminum case.

Grounding
To prevent ground loops, spurious oscillations etc. please take attention to:
- decouple the PCB in the chassis (housing)
- all connections and wire leads should be made as short as possible
- a proper PCB layout with enough ground surface ensuring normal ground paths
- the source of Q2 (IRF510) should also be grounded to the chassis as close as possible

-

ON6MU 5-band HF Power Amplifier



Specifications RE-PA30HF5B

- Allmode: AM/FM/CW/SSB/FSK
- Bands: 80m, 40m, 30m, 20m, 17m (or to be used for one separate band if you desire)
- Average output RF power: +/- 25W SSB PEP @ 24v , 13 watt SSB @ 13.8v
- Works great with Yaesu FT-817, Ramsey QRP rigs or any other 1-2 watt transmitters
  Input power drive: 0.4...2.5watt max (ideal 1...2watt)
- All modulation modes
- Efficient band-pass type harmonic L-filter + lowpass Butterworth PI filter
- Usable voltages: Vcc 13.8 - 25 volts
- Average current I: +/- 2.5A @ 24 v at full load
- Built-in T/R relay automatically switches between receive and transmit
- VSWR overload resistant (short period of time, not unlimited)
- Multistage band pass and low pass filter for a clean signal
- Manual band switching (if build for more then one band)


The 5-band HF power amplifier "insides"

The MOSfet 5-band HF Amplifier settings

Needlessly to say, but I will say it anyway, before testing anything please be sure to double check every connection. The project should be finished HIHI.
Connect a proper dummy load and a power meter to the output of the amp. Also put a Ampere meter in series with the Vcc, allowing monitoring of the current during the setup.
Set all trimmers (Ct1...Ct5) half way (in medium setting).
Set P1 to the ground (zero ohms).

Now gently increase the voltage to the amplifier while checking the current till you reach 18 volts. The only current you should see is a the liddle idle current of Q1 (a few milli amps and a a few mA of LED D3 if connected). We do not need the full 24 volts during the tuning/setting stages.

Now gently turn P1 till you get approx. 100 mA.

So far so good? Now we need to check if the (Q2) RF-sensing circuit is working properly (*Although I would like to recommend to test this before anything, rather then building the entire project and test it. Or at least before mounting the PCB in the alu-box, and without Q2 soldered. The RF-sensing ON-time can vary according to the relay used)*.
Connect your transceiver (or other drive) to the input, and set it to the lowest power rating of +/- 0.5watt and set your transceiver to 14.100Mc in CW/FM.
Be sure the dummy load is still at the output of the amp and the bandswitch is also set to 20m band.
Key your transceiver and if all goes well the relay (Re) should power up and you should see the current rise and your power meter should already show an amplification of the RF input power.

All working as planned? Excellent! Now we need to tune the filter-unit by setting the Ct's according to each band.
Set the drive power (your transceiver) to +/- 1...2.5 watts
Turn the band switch (S2) to 80m, as we start with the lowest band and work are way up from there. Also set your transceiver to the middle of the (each) band segment.
Carefully turn Ct5 till you get maximum output power (whilest checking the input SWR on your transceiver/SWR meter).
Current should be around 1.8...2 Amp +/- max (depending on the voltage and input power).
Next is to repeat the above for each band and setting the Ct capacitor trimmer(s) according to each band respectively.

After the filter is tuned in respect to each band you can increase the voltage to 24 volts. Then check everything again, band by band. Could be that you notice a slight difference in the peak output power, do to the capacity of the switch and the filter components. Just re-tune (if needed) each trimmer (Ct1...Ct5) for each band respectively.
The maximum current of the amplifier should never exceed 3 amps.

<u>RF-sensing considerations</u>
The basic principle of RF-sensing using a relay is clearly drawn in the schematic and pretty much self explaining. Q2 (BC338, 2N2222) will conduct when RF energy is applied at the input of the amp (via R10, C29, D3, D4, C30 biasing the base of Q2) hence powering up a RF capable relay. This relay switches between RX and TX with amp. When no Vcc is applied to our amplifier (and so Q2 too) no amplification is done bypassing the amplification. The input is simply re-directed directly to the output (as if your transceiver is connected without an amp). The RF sensing circuit is sensitive enough to react on .5 watt easily.
To allow the amplifier in SSB-modulation some extended PTT time-on the RF-sensing unit (Q2->relay) has to be increased. C31 adds the needed "breathing" time. In FM/CW/AM/FSK modes a carrier is present and extended PTT time-on of the amplifier isn't needed, hence can be short.
Important: Everything will be within specs if you use RY5W relay, but timing delay (the "breathing time") can vary on the type of relay used (Ohms resistance value of the relay coil), hence experimentation of C31 is needed.

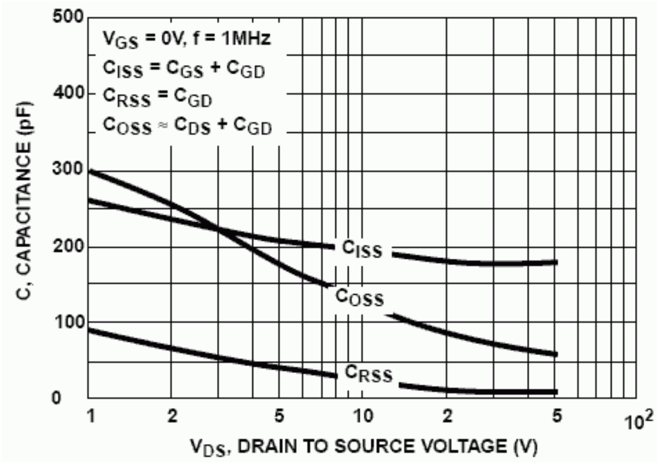
Although this example of RF-sensing isn't the Worlds most best sollution, it is pretty easy for beginners and effective though. Better would be to drive Q2 from your transceiver (amp drive) as this will switch the amp at the very moment of PTT.
Tip: I would like to recommend to add a mini-switch between C31 and GND if you plan to use it for CW. The delay is too long for CW.

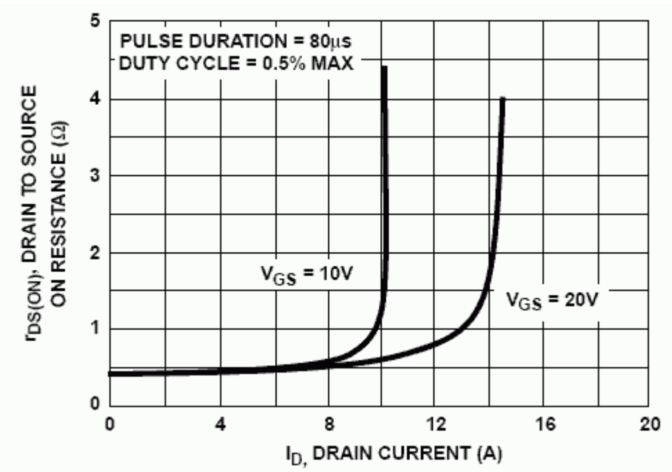
<u>Note:</u>
Always use a dummy load for testing and adjusting the amplifier!!!
Remember that this is a prototype.

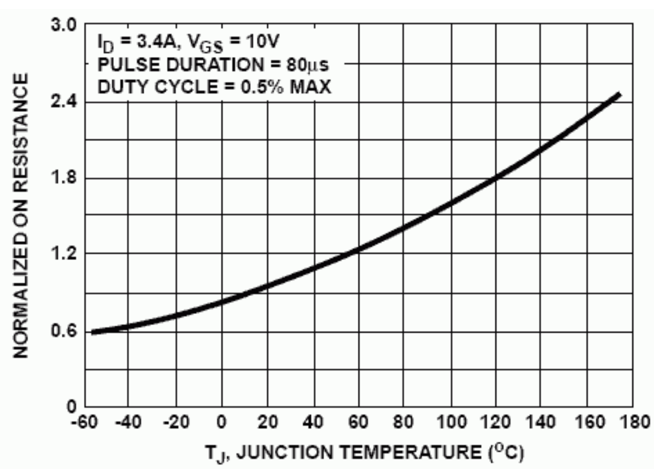
<u>Rev1.1 oct/09</u>

In the schematic D1 was shown in reversed state, hence could not set Bias correctly: fixed
Shunt Dr2 total turns was wrongly specified. Should be 20 turns instead of 35: fixed

<u>MOSFET specs:</u>



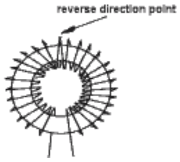




Coils

All we need to do now is make a few remaining coils that have to be handmade - for that "old-world craftsmanship" touch!
The wire used for the coils are enameled wire (stripped from any AC transformer).

Dr1: you need a ferrite core of 3mm diameter and about 5...8mm long. You wind 30 turns up and down the core, with no spacing. Wire used is 0.4mm enameled wire.



Dr2: Shunt made out of a small yellow/white toroid of +/- 13mm diamter (like those often found in PC switched power spupplies etc.). It has about 2 times 25 turns of 0.8mm enameled wire. Turn 25 turns closely together till you reach half way the toroid. Then reverse direction and make another 25 turns till you reach the end. This shunt is not too critical, so a few turns more or less will not cause any problem, but do not leave any space between the turns. Note: Also the toroid core type isn't ciritical, almost any type will do (*you can use a 'normal' wound toroid with no reverse direction if prefered, but the linearity may suffer a little.*).

Dr3: a ferrite bead where you turn a few times a 0.6 mm wire through.

L1: 2 turns, no spacing, 5 mm inside diameter, 0.6mm gauge enameled wire

L2: 22 turns close together of 1.2mm enameled wire. Inside diameter is 9.5 mm and 26.5 mm long

L3: You need a ferrite core 14mm long (I broke a piece of a ferrite core like found in those old AM-radio's) and wind 11 turns close together of 1.2 mm enameled wire over the core. Inside diameter of the core is 9.5mm

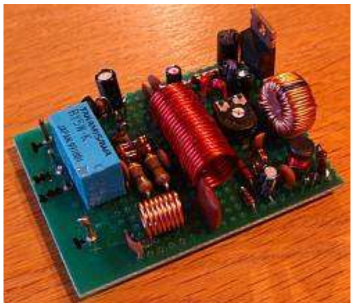
L4: 8 turns close together of 1.2 mm enameled wire. Inside diameter is 6.5mm and is 9.6mm long

Tip: remember to vernish or glue-fix the coils to prevent FM'ing do to vibrations

Parts list 5-band HF power amplifier

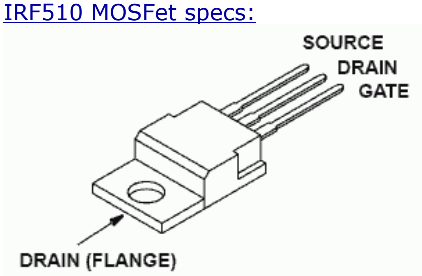
- Q1: N-Channel IRF510 MOSFET
  (with proper heatsink isolated from the mosfet)
- Q2: NPN BC338/337, 2N2222...
- IC1 = 78H05 or 78L05
- C1: 100n
- C2: 1uF/50v
- C3: 1uF/16v
- C4: 100n
- C5: 2.2uF/50v
- C6: 100n
- C7: 4n7
- C8: 10n
- C9: 47uF
- C10: 100n
- C11: 47n
- C12: 1uF/16v
- C13: 68n
- C14: 100n
- C15: 100n
- C16: 39, ceramic 200v
- C17: 68, ceramic 200v
- C18: 180, ceramic 200v
- C19: 2 x 150pF parallel (or 330), ceramic 200v
- C20: 2 x 220pF parallel (or 470), ceramic 200v
- C21: 100, ceramic 200v
- C22: 220, ceramic 200v
- C23: 220, ceramic 200v
- C24: 470, ceramic 200v
- C25: 1200, ceramic 200v

- C26: 220, ceramic 200v
- C27: 100, ceramic 200v
- C28: 2n2
- C29: 470p
- C30: 47n
- C31: 68uF/tantalum 16v (determines the ON-time for RF-sensing)
- C32: 150n
- R1: 47 1/2w
- R2: 390 1/2w
- R3: 47 1/2w
- R4: 47 1/2w
- R5: 390 1/2w
- R6: 1k
- R7: 1k
- R8: 10 1/2w
- R9: 18k
- R10: 1k
- R11: 1k
- P1: 5k potentiometer (BIAS setting Q2)
- D1, D3, D4: 1N4148
- D2, D5: 1N14001
- S1: Toggle switch (ON/OFF-Bypass)
- S2: 5-position quality switch (if possible silver plated)
- Ct1: 20pF ceramic or air-spaced trimmer
- Ct2: 30pF ceramic or air-spaced trimmer
- Ct3: 60pF ceramic or air-spaced trimmer
- Ct4: 60pF ceramic or air-spaced trimmer
- Ct5: 100pF ceramic or air-spaced trimmer
- 2 x SO239 connectors
- Re: RY5W-K relay
- F1 = 4 amp
- Alu-box
- Heatsink + thermal grease
- Dr1: ferrite core 3mm diameter, 5...8mm long. 30 turns, 0.4mm wire (+/- 4.7uH)
- Dr2: yellow/white toroid of +/- 13mm diamter, 2 x 20 turns of 0.8mm wire
  Note: the type of toroid isn't too critical, so almost any core will do. It could be that some experimentation is needed to find the optimum value.
- Dr3: a ferrite bead with 4 turns of 0.6 mm wire
- L1: 29nH; 2 turns, no spacing, 5 mm inside diameter, 0.6mm wire
- L2: 1.4uH; 22 turns close together, 1.2mm enameled wire. Inside diameter is 9.5 mm
- L3: 3.8uH; ferrite core 14mm long, 11 turns close together, 1.2 mm enameled wire. Inside diameter 9.5mm
- L4: 410nH; 8 turns close together of 1.2 mm enameled wire. Inside diameter is 6.5mm



Note: the caps C16 till C27 may have higher voltage specifications, but no less then 150v.

IRF510 MOSFet specs:



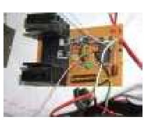
Drain to Source Voltage . . . . .VDS: 100 V
Drain to Gate Voltage (RGS = 20kW) . . . . .VDGR: 100 V
Continuous Drain Current . . . . .ID: 5.6 A
TC = 100oC . . . . ID: 4 A
Pulsed Drain Current . . . . IDM: 20 A
Gate to Source Voltage . . . . VGS: ±20 V
Maximum Power Dissipation . . . . PD: 43 W
Linear Derating Factor . . . . 0.29 W/C°
Single Pulse Avalanche Energy Rating . . . . EAS: 19 mJ
Operating and Storage Temperature Range . . . . TJ, TSTG: -55 to 175 C°
Input Capacitance . . . . f = 1.0MHz - 135 - pF
Output Capacitance . . . . COSS - 80 - pF
Reverse-Transfer Capacitance . . . . CRSS - 20 - pF
Internal Drain Inductance LD Measured From the Contact Screw On Tab To Center of Die 3.5nH
Pulse Source to Drain Current . . . . .ISDM - - 20 A
Source to Drain Diode Voltage VSD TJ = 25C°, ISD = 5.6A, VGS = 0V. . . . . 2.5 V

LT-Spice simulations

here

Pictures of users who build the project

This is how John SV1ONK did it:

He made it for the 20-meter band.

Thanks John!

This how Konstantinos SV1ONW made it:

Thanks Konstantinos!

Little note on Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...).

A resonant antenna is an absolute requirement for QRP operation, and an amplifier is not a "band-aid" for a poor antenna system!
We cannot expect good results from low levels of RF output if the power gets wasted in lousy coax, corroded connections, or poor antennas. Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150 / freq - 5%).

Another related project:
..15 & 17 meter band transistor 10 watt amplifier

Remember that transmitting and/or using an power levels higher then your local license permit is illegal without a valid radioamateur license!

ON6MU
Home

ON6MU

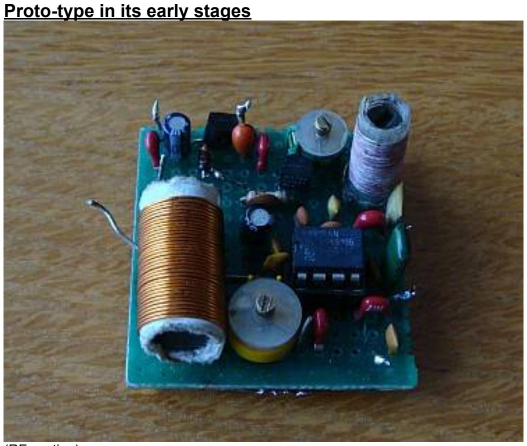
RX1HF80: 80m SSB/CW/AM Receiver

prototype
most recent update 11th of January 2012

About RX1HF80

I wanted to make a compact battery powered 80m band SSB receiver. Not only that, it should also be sensitive receiver and a simple design. I had experience with the SA612 double-balanced mixer (8 pin IC) (check out my Magic-band converter and my DRM converter), but I did'nt want to make a converter. It really had to be stand-alone little receiver. After a whole lot of time experimenting and burning up a few components in the progress I finally had a proto-type. It is not too complicated, but some experiance to build it yourself will be needed.
Also, my proto-type was build upon a experiment copper square PCB. I used that so I could change things easier while I was desinging/making it. I have to stress out that it wont work properly using such a experminal printboard!

Proto-type in its early stages

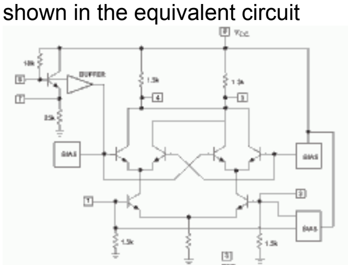


(RF section)

I got it to work by keeping it small, using very short connections and made the ground connections large so no RF loops would occur. The dead-bug methode could probably work too although I did not test it. I really need somebody who can make a PCB for the RX1HF80!! Anybody out there? Anyway, it can be done using a cheap circuit board **IF** you take real good care of the connections and ground paths hence honoring the principles on building (V)HF projects. And keep the audio stage and HF part separate. Of course when we can find a PCB designer for this project all sections of the receiver could be on the same PCB.

SA612 Mixer

The heart of the receiver is the SA612A is a low-power monolithic double-balanced mixer with on-board oscillator and voltage regulator. It is intended for low cost, low power communication systems with signal frequencies to 500MHz and local oscillator frequencies as high as 200MHz. The mixer is a "Gilbert cell" multiplier configuration which provides gain of 14dB or more at 45MHz. The oscillator is configured for tuned tank operation. The low power consumption makes the SA612A excellent for battery operated equipment. Also you'll benefit from very low radiated energy levels within. The SA612A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -15dBm (that's approximately +5dBm output intercept because of the RF gain). It also has a temperature compensated bias network as shown in the equivalent circuit



It works pretty well in this receiver, but in practice it shows some intermodulation when signals are strong. That is why I added a bandpass front-end filter. It greatly reduced the intermodulation.

What kind of radio is it?

You can listen to SSB signals (actually like the SA612 is used here it demodulates LSB and USB more like a DSB). It does not separate LSB and USB. CW can also be received as can DSB. AM is tuned like with any SSB receiver to the dominant frequency peak meaning the middle of the AM signal (zero-beat). Anyway, because I wanted to keep the simplicity of the project I opted for direct conversion. Direct conversion means that you process the incoming RF signal at its frequency without down converting it to an IF (Intermediate Frequency) and then processing the IF frequency. Direct conversion single sideband receivers are of interest because they are less subject to spurious responses than the conventional superheterodyne, do not entail the use of high-gain narrowband amplifiers with high centre frequency, and lend themselves better to integration in monolithic form.
The most important feature of a direct-conversion SSB transceiver is that there are no complicated conversions nor image frequencies to be filtered out. However, the RF section of a direct-conversion SSB transceiver requires simple LC filters to attenuate far-away spurious responses like harmonics and subharmonics.
This direct-conversion SSB transceiver includes some critical components like precision (1%) resistors en quality capacitors to ensure its stability. Do not dismiss this, it is important.

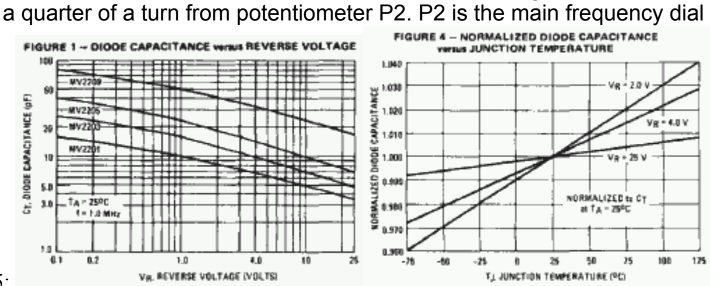
Design tips

To keep the receiver stable as possible and without frequency drifts you need to use components that has good temperature qualities. I can not emphasize it enough how important this is! Using low quality junkbox components will cause a unstable receiver. I have marked the critical components with an asterisk * .
For * resistors: please use metal film 1%
For * capacitors: please use mika, polystyrene or multilayer ceramic capacitor (*multilayer ceramic capacitor has a many-layered dielectric. These capacitors are small in size, and have good temperature and frequency characteristics*)

Notes: I got it to work by keeping it small, using very short connections and made the ground connections large so no RF loops would occur. The dead-bug methode could probably work too although I did not test it. I really need somebody who can make a PCB for the RX1HF80!! Anybody out there?
Anyway, it can be done using a cheap circuit board **IF** you take real good care of the connections and ground paths hence honoring the principles on building (V)HF projects. And keep the audio stage and HF part separate.

MV2205 Varactor and tuning

The receiver tunes using a varicap (Capacitance Varactor Diode). If you can not find the MV2205 you can use a BB409 (**see text below*). Anyway, I could use the entire very broad 80m band with both types of varicaps. With other types you probably will need to adjust C17 and C20 and perhaps R1, or R2, or R3 or R4 or a combination. It will come down to get a full 80m band coverage and a proper bandspread. We do not want the entire band in a quarter of a turn from potentiometer P2. P2 is the main frequency dial and P1 allows fine tuning.

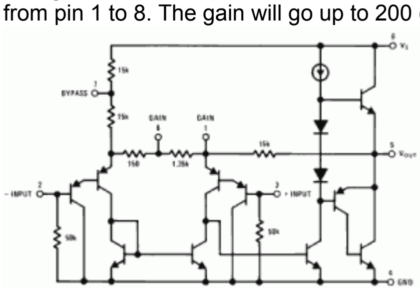
MV2205:


BB409 Varactor

I have been experimenting using the popular and easy to find BB409 Varactor Diode. It has a max capacity of 32pF. Comes close to the MV2205, but the lowest capacity is a bit more different hence changing a few components was necessary. Also the temperature coefficient of the diode capacitance is slightly inferior, but it causes no problems. It does the job. So what componenets needs to be changed when using a BB409 instead? You can leave out C17 and replace C20 with a 220pF component. That's it.

Audio

The audio is power by is a black box LM386 audio amplifier. The LM386 has enough gain to drive a small speaker and it designed for use in low voltage consumer applications. Ideal to use in battery fed applications. The gain is set to the max in this project and not only by using a capacitor from pin 1 to 8. The gain will go up to 200 (46 dB) and additional amplification and audio bandwith range with R7 C32.



Set and calibrate

To set and calibrate the RX1HF80 we need minimum:
- a 'real' accurate receiver or transceiver that is capable of receiving 80m SSB

Although most can be done by "ear" It also helps to have a frequency counter and a RF voltage meter.

First we need to tune the Local Oscillator LO (Colpitts) varactor tuned tank circuit C19 & L1. This need to be set to 80m band. With C19 and L1 you can easily tune between 3Mc and 4.5Mc. The SA602/SA612 double-balanced mixer will mix the incoming RF with LO.
Use a frequency counter or your receiver/transceiver and place a wire from the antenna connector in the proximity of the tank circuit. You'll should hear/see your signal on your radio.

Now we need to peak the front-end tank circuit C9 & L3/L2. This needs to be tuned for maximum peak/sensitivity on the 80m band (preferably in the middel of the band). Tuning C9 will probaly do the trick (in some cases moving the core of L2/L3 can achieve further tuning if needed).

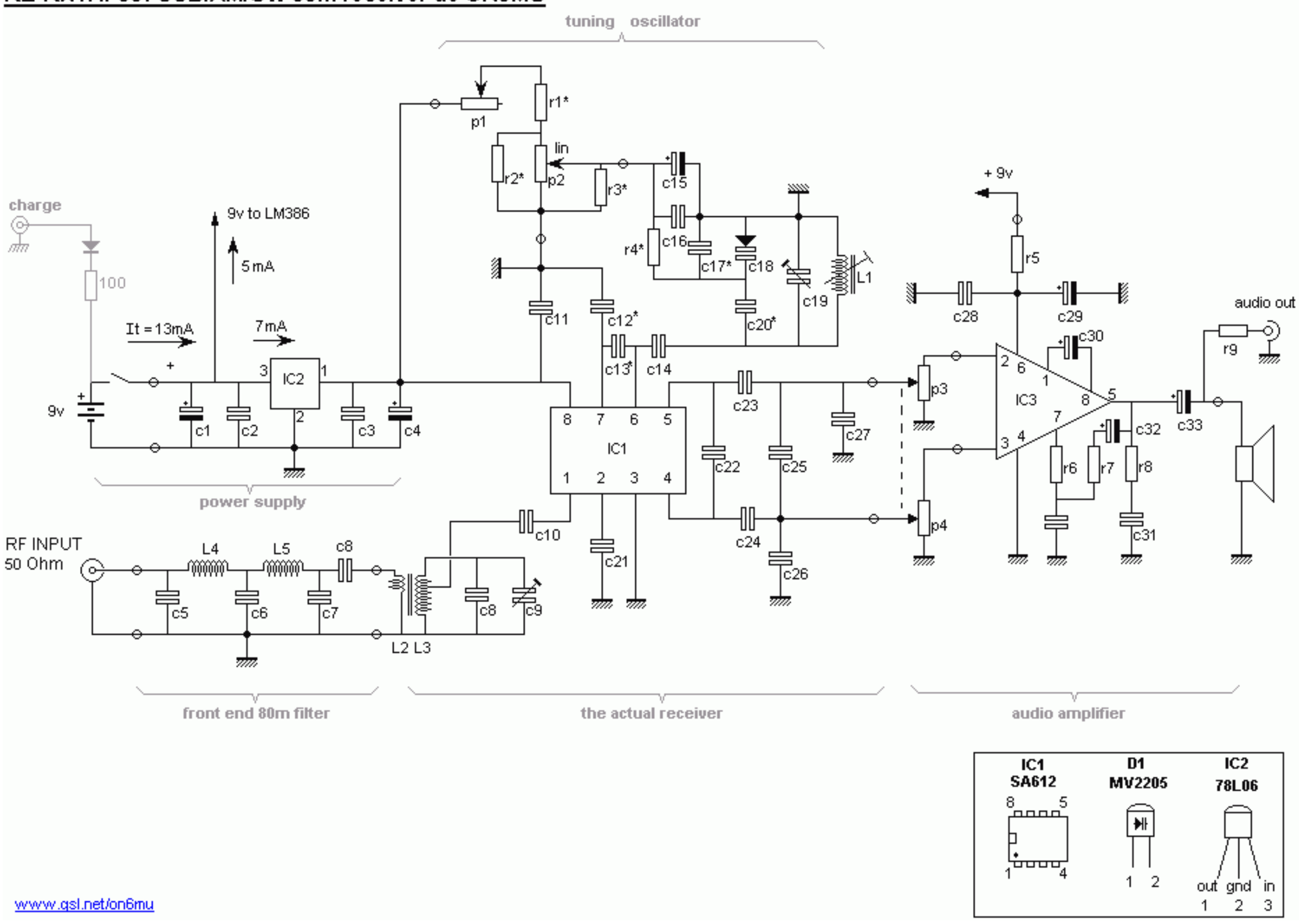
Specs

- Frequency range: 3000 kHz - 4300 KHz (*maximum range with existing components, not the actual tuning range*)
  Note: although the kit can be set to tune anything from 3 to 4.5mc, the design however is made to RX peak in the 80 ham band.
- Tuning range: 400kc+/- typ. 3500...3900Mc
- Varactor tuning
- +/- 1 kc fine tuning (*can be set to other ranges, see text*)
- Modes: USB, LSB, DSB, CW, AM (*I was able to decode sstv, rtty and even psk31*)
- Sensitivity: +/- 0.25uV @ 12dB SINAD
- Mixer noise figure typically lower then 6dB
- Input impedance: 50 Ohm
- AF amp gain 46dB
- AF s/n ratio +/- 80dB
- AF distortion: 0.5% (AV = 20, VS = 6V, RL = 8W, PO =125mW, f = 1kHz)
- Drives a 4...8 Ohm speaker with 500mW output LF power @ 9volts
- U = 8...15 volts when external power operated (9v battery works perfectly too)
- I = 13mA @ 9volts (digital version only 7mA)
- connector for external charging and a connector for LF output (external amp, PC, to decode digimodes as sstv etc.)

Schematics

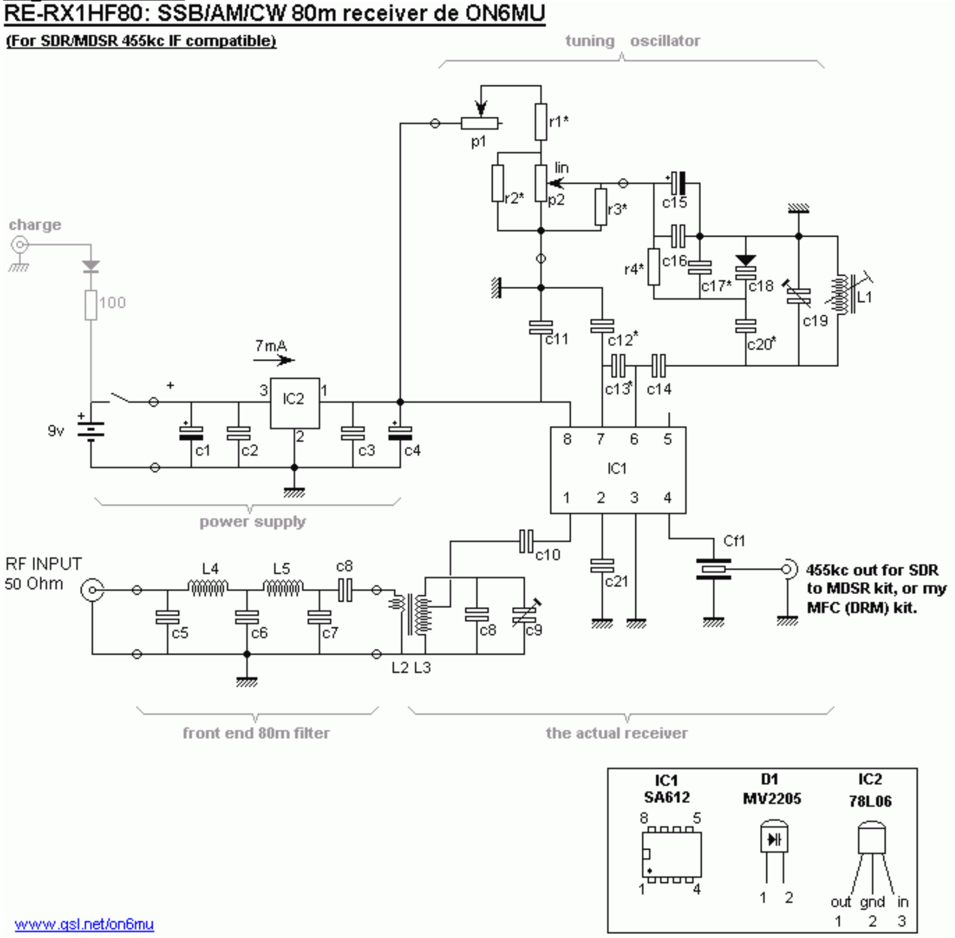
Analog version

RE-RX1HF80: SSB/AM/CW 80m receiver de ON6MU



Digital version

RE-RX1HF80: SSB/AM/CW 80m receiver de ON6MU



Use the above schematic if you want to use the receiver with MDSR, or with my MFC/DRM demodulator (or with other 455kc

demodulation kits). The LO needs to set slightly differently then in our analog version. It needs to be shifted 455kc up. MDSR software is recommended, however it works fine with other compatible software, like SDRadio, too.

Part list (normal analog version)

- IC1 = SA612AN, SA602, NE602, NE612
- IC2 = 78L06
- IC3 = LM386
- R1 = 1k2 1% metal film (*infuences the bandspread*)
- R2 = 10k 1% metal film (*infuences the bandspread and linearity)*
- R3 = 2k2 1% metal film (*infuences the linearity hence even spread of the frequencies with the pot)*
- R4 = 38k 1% metal film (*this value influences the bias of the varicap hence also the tunable range; LO frequency)*
- R5 = 10
- R6 = 1k5
- R7 = 2k2
- R8 = 10
- R9 = 380
- P1 = 470 (*fine tuning; adjust to aquire other fine tune ranges*)
- P2 = 10k linear (*main tuning)*
- P3 = 22k stereo potentiometer
- C1 = 22uF/25v
- C2 = 100n
- C3 = 100n
- C4 = 10uF/16v tantalum
- C5 = 560
- C6 = 2n2
- C7 = 820p
- C8 = 30p
- C9 = 40p trimmer (yellow)
- C10 = 1000p
- C11 = 1000p
- C12 = 100p (*mika, polystyrene or multilayer ceramic capacitor)*
- C13 = 100p (*mika, polystyrene or multilayer ceramic capacitor)*
- C14 = 1000p
- C15 = 1uF/16v
- C16 = 10n
- C17 = 10p (*mika, polystyrene or multilayer ceramic capacitor)*
- C18 = MV2205 Capacitance Varactor Diode (*others can be used, but the oscillator, spread and tunable range probably needs some attention*)
  ....Or a BB409 varicap*(*C17 needs to be removed, and C20 needs to be changed to 220pF, please see text for more info).*
- C19 = 30p trimmer
- C20 = 560p (*mika, polystyrene or multilayer ceramic capacitor)*
- C21 = 47n
- C22 = 4n7
- C23 = 100n

- C24 = 100n
- C25 = 6n8
- C26 = 4n7
- C28 = 100n
- C29 = 47uF/25v
- C30 = 10uF/16v
- C31 = 100n
- C32 = 1uF/50v ?
- C33 = 330uF/16v
- L1 = 40 turns, 0.2mm litze (AWG#32), 7mm diameter
- L2 = 3 turns, 0.5mm (AWG#24), 10mm diameter (L2 and L3 are on the same core)
- L3 = 30 turns 0.5 (AWG#24), 10mm diameter, a tap at 10 turns from the top
- L4 & L5 = 35 turns, 0.3mm (AWG#28), 6mm diameter
- Cinch female (audio output)
- SO239 (antenna connector pl259)
- 9v rechargeable battery
- 8 Ohm 0,5w speaker (YD58-2)
- Alu case 120x45x75 (or bigger ;-)
- *All resistors can be 1/4watt or 1/8watt, except R5 that needs to be a 1/4watt type*

Details - Coils

L1: 40 turns, 0.2mm litze (AWG#32), 7mm inside diameter, 13mm long, adjustable ferite core. Core needs to cover the entire length no longer. (L1 = local oscilator resonant @ 80m). *(Ideal would be to shield the LO, but this I could not do because of the small pcb I was forced to use in this prototype)*

L2: 3 turns, 0.5mm (AWG#24), 10mm inside diameter (close to the hot side of the coil, being the top as seen in the schematic)

L3: 30 turns 0.5 (AWG#24), 10mm inside diameter, 17mm long, fits over a ferrite rod (the core can be 'recycled' from an old transistor radio). A tap @ 10 turns.
Important: both L2 and L3 are on the same ferrite core. L2 is wound against the hot side of the coil. The tap on L3 is closest to the hot side. Core needs to cover the entire length no longer.

The main resonant tank L2/L3 coil is best wound over a bit of thin cardboard, paper or plastic that snugly fits over the ferrite rod. The coil can then be slid along the rod to adjust the maximal sensitivity if needed (in combination with C9). Mostly the core just covers the entire coil length.
Use this to set the peak the centre frequency the band.

L4 and 5: 35 turns, 0.3mm (AWG#28), 6mm inside diameter, 15mm long. I used a piece of plastic shaft from a potentiometer as "coil holder".

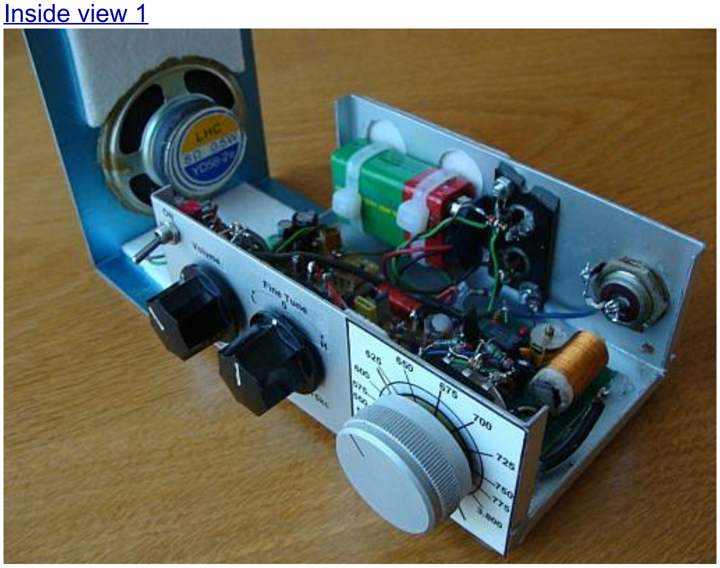
Tips and suggestions:
- use external freq counter to read frequency instead of the analog scale. *(you could then use a 5 or 10 stroke P2 and leave out the fine tuning P1)*
- use a stereo pot (P2) and drive a analog meter to be used as frequency scale readout. Or even a digital meter! *(also here you could then use a 5 or 10 stroke P2 and leave out the fine tuning P1)*

- use a RF-gain ciruit (or use a RF dampening circuit: like a 5K pot that provides gain control by shunting some of the signal to ground).
- an AGC circuit. Could probably be build around the existing LM386 and using that amp to reduce AF gain on strong signals, or an extra amp to function as agc just before the lm386 input....
- when we have found a PCB designer for this project it could easily be build as a portable receiver (handy) and later on design a TX circuit...

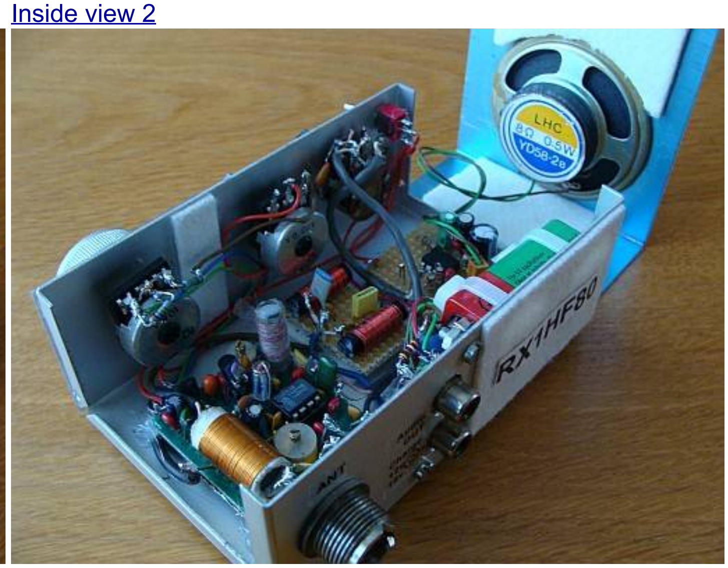
[top view]

From left to right: Receiver, Filter, Audio

[Inside view 1]



[Inside view 2]



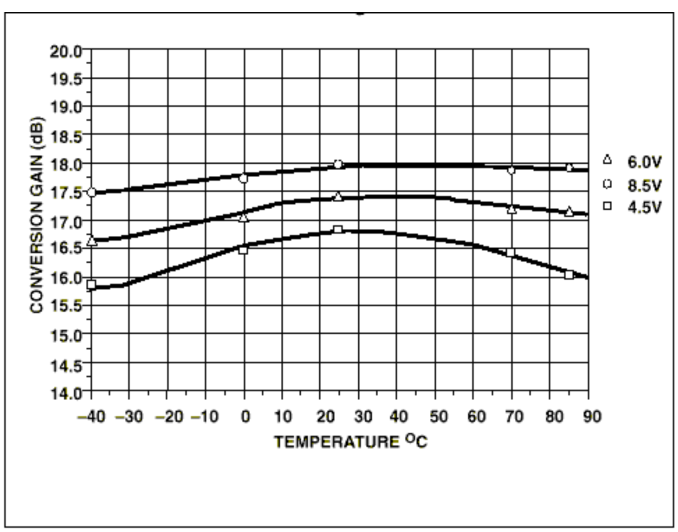


Figure 3 . Conversion Gain vs Supply Voltage

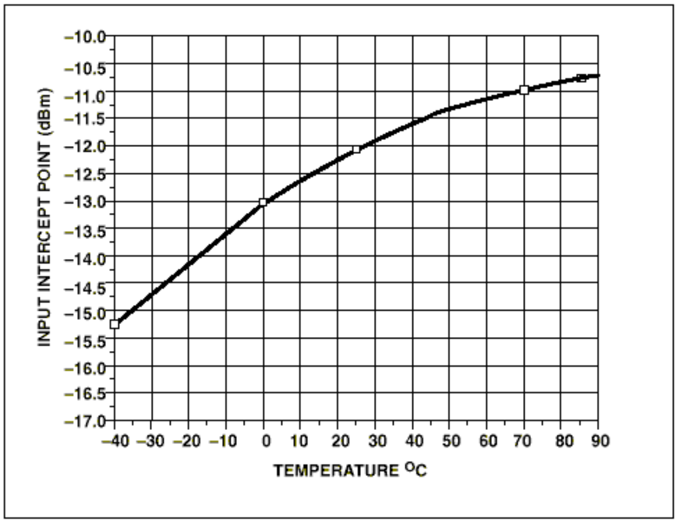


Figure 4 . Third-Order Intercept Point

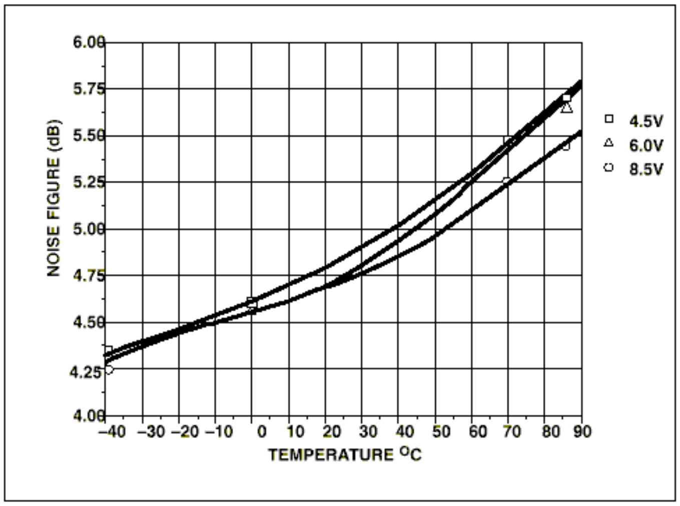


Figure 5. Noise Figure

Also more of my homebrew projects:

[ON6MU Homebrew projects]
Radioamateur related projects
[ON6MU Ham mods]
Modifications of transceivers

..[ON6MU 50 Mhz converter/receiver]
..Magic band converter

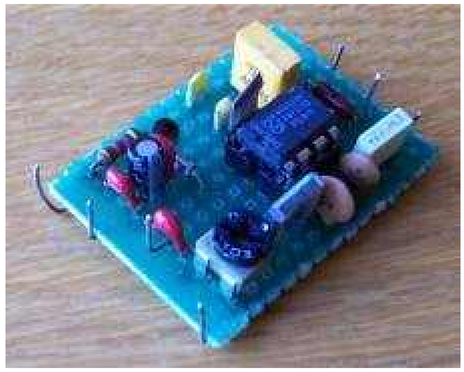
73"

ON6MU
[Home]

Radio kits velleman. Radio converter kits. Kenwood, Yaesu receivers. Electronics schematics of radios. Building kit of a home made crystal radio with transistor components. Receiver commercial receiving antenna. shortwave listening with receivers. Build your own shortwave receiver. Performance not as a Kenwood or Yaesy receiver but so much more fun to receive world wide signals. Not using integrated circuits. Circuits integrated components of electronical contents. Antenna longwire for shortwave reception.

DRM
MF 455kHz -> AF Converter
RE-RXC0455/0012
(455kHz down converter)

MFC revision 1.4



MF (455kHz) to AF (audio frequency) Converter/Interface
to receive DRM singals your shortwave receiver, like the Yaesu FRG-100!
and FT-817/897

Please take also look at our Digital Analog Demodulation Project (DADP, VE7DXW)

Attention! The modification will be done at your own risk!

About the MF-LF converter/mixer RXC455/0012:

This is a very sensitive homemade MF converter/interface allowing you to receive the DRM radio (Digital Radio Mondiale) with your general coverage receiver and a soundcard. It can also be used for software radio apllications, and other MF to LF experiments (not just DRM, and surely not just for the Yaesu FRG-100)!
I've tested this project on a allmode Yaesu FRG-100 receiver. Within certain limits you can change the output bandwidth frequency to suit your needs. The converter is very stable, low noise, sensitive and low on power consumption.
The heart of the converter has been built around Philips SA602 (NE602, NE612, SA612), a twice balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 13mA. Therefore also uncomplicated usable applications fed with battery if needed, but in this converter's DRM application I use the voltage of the receiver itself.

The SA602A is a low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator. It is intended for high performance, low power communication systems. The guaranteed parameters of the SA602A make this device particularly well suited for cellular radio applications. The mixer is a “Gilbert cell” multiplier configuration which typically provides 18dB of gain at 45MHz. The oscillator will operate to 200MHz. It can be configured as a

crystal oscillator, a tuned tank oscillator, or a buffer
for an external LO. For higher frequencies the LO input may be externally driven. The noise figure at 45MHz is typically less than 5dB. The gain, intercept performance, low-power and noise characteristics make the SA602A a superior choice for high-performance battery operated equipment. It is available in an 8-lead dual in-line plastic package and an 8-lead SO (surface-mount miniature package).

Revision 1.1(June 09)
I have added a low noise transistor (Q1) to amplify the output to a more convenient level, as I noticed that the audio level was just below the ideal level on one PC, whilest on my laptop the level was enough. Remember to set the ideal audio volume level if needed from within your OS.
R4 (already existing in rev.v1.0) and C13 gives some additional filtering of the LF signal.

Revision 1.2(Nov 09)
I have noticed that by adding C17 hence limiting the highest frequency responce and amplifying the lower 5...20kC gave additional improvement.
P (trim pot) of 2k5 to allow exact LF output level setting for your soundcard input
Voltage for Q1 now also 6 volt (tapped from IC2)

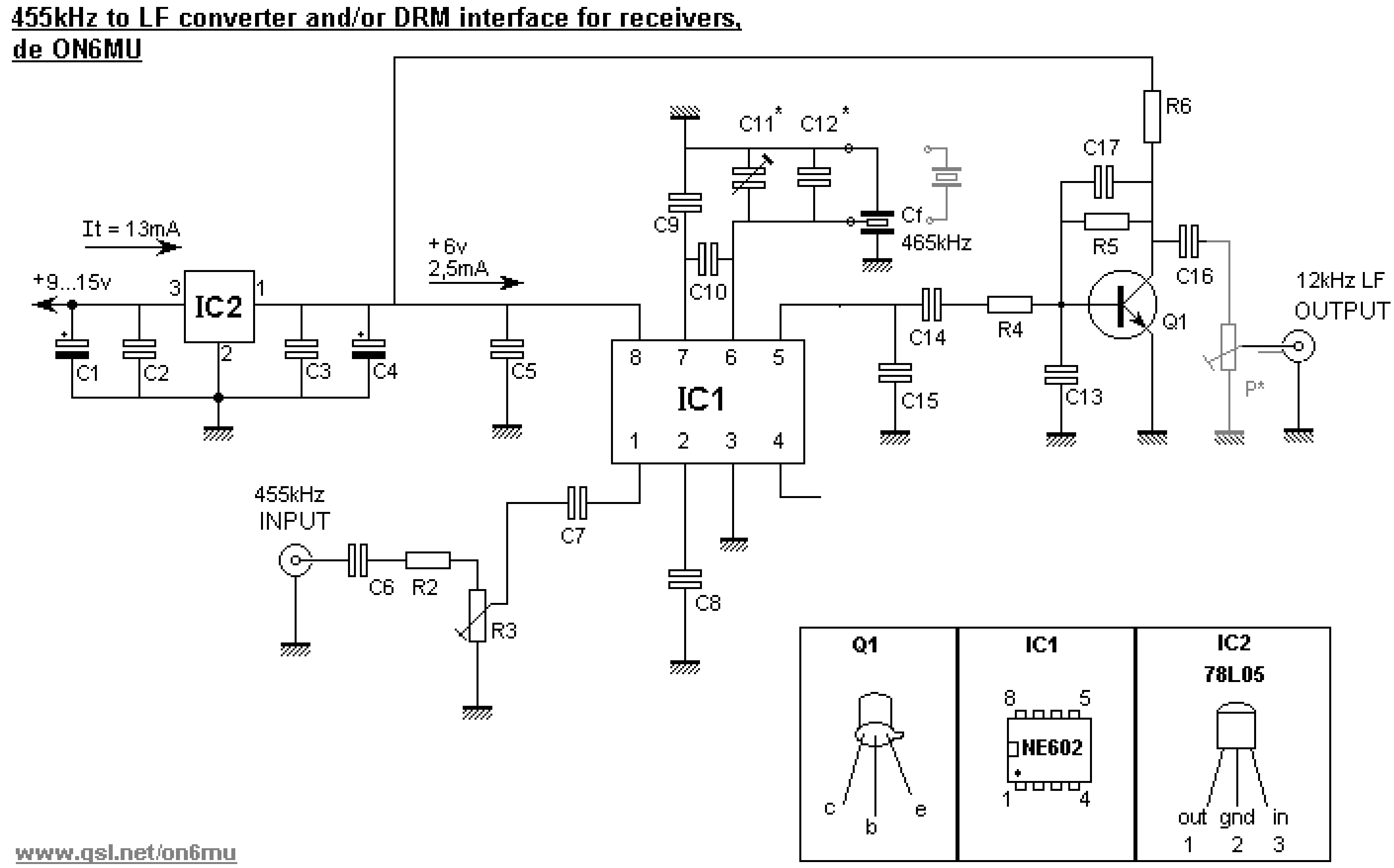
Revision 1.3b(Nov, 21th 09)
C19 & C18 added as it gave a noticable cleaner signal but lower LF output
R7 removed to compensate lower LF output
v1.3b: C18 added

Revision 1.4(Nov 14)
Changed the extractionpoint from the FRG
Some components left out to simplify the project further

RXC0455/0012 455KHz converter technical specifications

- Frequency range from 455kHz...467kHz
- LF/AF out 100...12kHz
- Power supply = 9...18v max
- Total power consumption = 13mA
- Power consumption IC1 = 2,5 mA
- Sensitivity = 0.22uV at 12dB SINAD
- Mixer noise figure = 4,6dB
- Input impedance = 3k
- Output impedance = 1k
- Local oscillator 467kHz
- Frequency stability = +/- 5Hz
- Operating ambient temperature range = -40 to +85°C

RXC0455/0012 SCHEMATIC



PARTS

IC1 = NE602/SA602 or NE612/SA612 (all pin compatible)
IC2 = 78L06
Q1 = BC109,BC107
C1, C4 = 2.2uF/25v
C2, C3 = 100nF
C5 = 470pF
C6 = 100nF(polyester)
C7 = 68nF (polyester)
C8 = 100nF
C9 = 1nF
C10 = 820pF
C11= 100pF trimmer
C12 = 220pF
C13 = 1n5 (poly) *v1.1*
C14 = 220nF (polyester)
C15 = 2n2 (mylar,poly)
C16 = 220nF (poly) *v1.1*
C17 = 120pF *v1.2*
Cf = 465B (ZTB465 kHz, or 470kHz) ceramic filter resonator
R1*= 10k (not specified in the schematic, see text)
R2 = 1k8
R3 = 10k
R4 = 1k
R5 = 100k (*v1.1*)
R6 = 2k2 *(v1.1)*
P* = 2k5 (*v1.2*)

Ceramic resonator:
Cf is a simple 465 khz ceramic filter (3 pin or 2 pin version can be used). These can sometimes be found in a AM/FM transistor radio, old wireless telephones etc.

Ideal would be a quartz version as this offers best stability and accurate resonating frequency of the mixer.
There are many out there that are not exactly on frequency! When using it for DRM the mixing frequency is not critical, so you can use a 470 kHz type too.
If the bandpass is not 12 kHz and the frequency is too high you will need to adjust the mixing frequency Cf by using C11.
If the bandpass does not reach 12kHz because of the mixing frequency being too low you will need to add a capacitor in series with the ceramic resonator Cf, something between 100pF and 300pF. I would recommend starting with 150pF (or use a trimmer).
- ceramic filters can be order here (only EU)

What's DRM

The Digital Radio Mondiale (DRM) purpose is to develop a non-proprietary technical standard for the replacement of analogue AM (Amplitude Modulation) radio with digital radio, also called DRM.

As a replacement for AM the existing channel spacing, medium and long wave 9 kHz and 10 kHz for short wave, is maintained. On medium wave a DRM radio broadcast can provide close to FM audio quality - most people will relate to the poor audio quality of AM music. With DRM the audio quality is primarily determined by the broadcast mode and spectrum occupancy (i.e. radio bandwidth of the DRM signal).

It also the displays the name of the radio station, program text, and automatic tuning to alternative frequencies will make DRM receivers easier to operate. DRM can also transmit multimedia html pages and data.

If you listen to a DRM signal on an ordinary short-wave AM radio then all you will hear is noise. There is no discernible modulation pattern when listening to DRM using a AM demodulator.
DRM Stations recent schedule list

The (DRM) converter explained using a Yaesu FRG-100

There are examples enough around which use another filter by replacing the original LF-H2S with a 12kHz or 15kHz wide filter. This allowed the user to use DRM reception by selecting the AM-narrow mode. The MF output is there tapped from the (hot) connection of VR1002 as seen from the front panel to the IF input of the converter(mixer).
In this modification I use the unused CW-filter connections hence avoiding to remove the top board and soldering/replacing the stock AMN filter. However, both methodes work.
Note: In this example DRM-mode is selected by selecting CW/N mode on your FRG-100.

Calibrating

The converter is best calibrated to fit 12 kHz wide LF output. C11 and C12 primary determines the offset of the base resonating frequency of the 465kHz filter. With a frequency counter you can check the resonating frequency which should be around 467kHz. The converter/mixer outputs 467-455=12kHz wide AF output to be fed to your PC's soundcard input.
Set C11 to get as close as possible to 467kHz. It is possible that C12 need to be changed to if the desired frequency isn't reached.
I have found that it isn't too critical, although calibrating gives the best result. However, it should work as is (set C11 to half way).
Set R3 to the best signal/noise ratio, hence also setting the maximum output of the converter.
Note:
You can add a trim pot of +/- 2k5 at the output of Q1 after C16 to set the ideal output for your soundcard input.

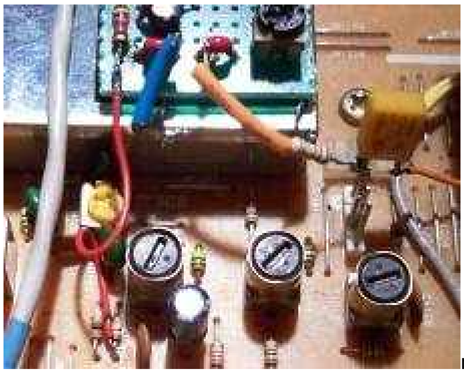
If the bandpass is not 12 kHz and the frequency is too high you will need to adjust the mixing frequency Cf by using C11.

If the bandpass does not reach 12kHz because of the mixing frequency being too low you will need to add a capacitor in series with the ceramic resonator Cf, something between 100pF and 300pF. I would recommend starting with 150pF (or use a trimmer).

Power source voltage

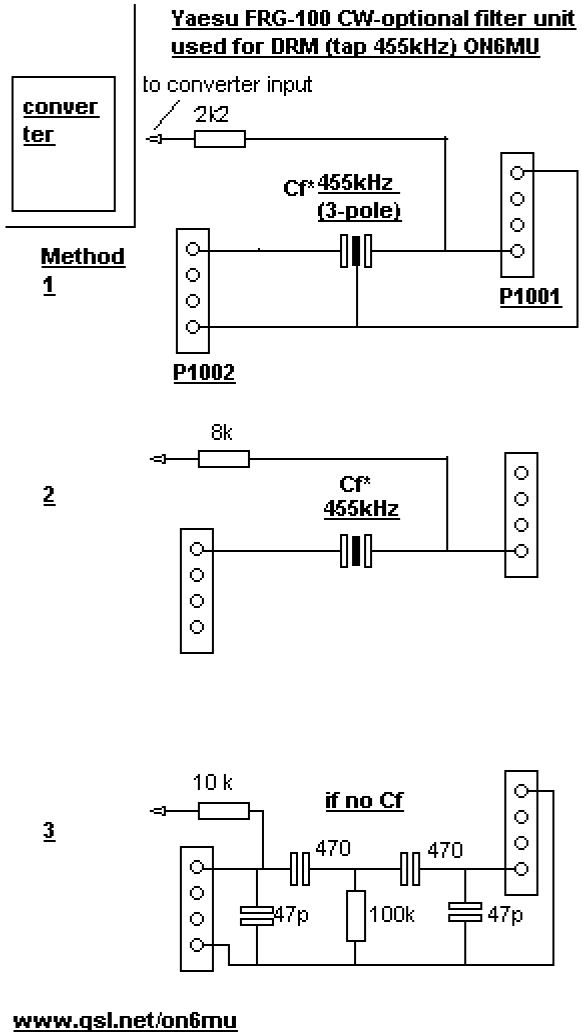
The converter Vcc voltage can be tapped from just about anywhere in the FRG-100. You can use the 12 volt input, or tap from the 9volts running allover the board. Tap often used is R1074 (closest to the front to the UB connection of the mixer board) where you find +9volt.
Any voltage from 8 to 18 volts can be fed as the converter uses a 78L06.

Using the CW/N optional filter connections


red wire is the +9v tapped from R1074, 47k resistor and ceramic filter is connected to the CW/N filter connector to get MF

It is perfectly possible to use the CW/N filter connections of the FRG-100 to tap the MF 455kHz...465Khz to feed it to our converter/mixer.

Use a 455kHz filter of 12...50kHz (often found in those old FM transistor radios etc.). This is soldered between pin 1 (top one) of CW/N filter connector P1002 and pin 4 of P1001 (bottom pin). A 47k resistor from P1002 pin 1 is fed to the input of the converter.
If you can not find such a ceramic filter (doubt it) you can replace it by a few caps (this is not a drop-in replacement, but workable enough to use for DRM with good signals till better is found).



Note: DRM-mode is selected by selecting CW/N mode.

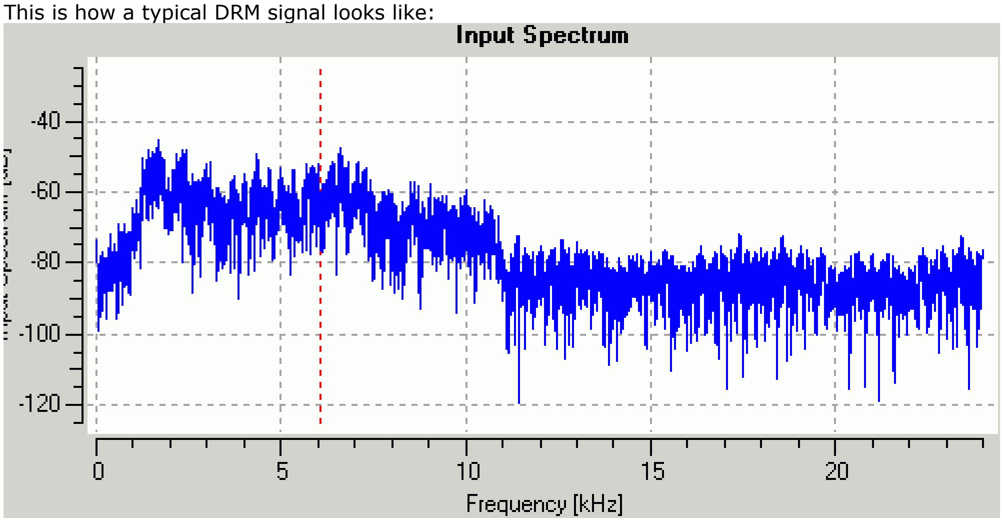
I soldered several of the converter grounds to the VFO chassis (approx. middle of the picture)
You can see the yellow/greenish 455kHz 20kc ceramic filter (between the converter and the FM-unit)
On the right side you can see my homemade FM-module based upon the Yaesu schematic found in the manual.

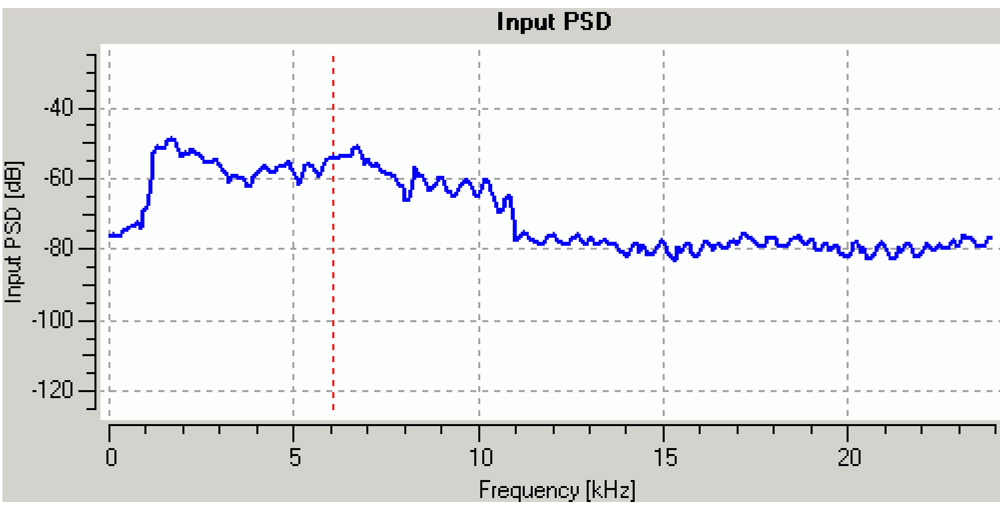
Output/tuning/setting

The output of the converter is fed to your soundcard using a female connector (on the backside of the receiver). I drilled a hole at the back of the FRG-100 to mount a 3.5mm female connector. Use shielded wire to connect the converter to the connector.
R3 sets the maximum level of the MF signal supplied, hence adjusting R3 can improve the signal-to-noise ratio depending on the input sensitivity of your soundcard and/or do to the MF voltage

input. Set R3 to 80% to start with. Adjust the adjustment on the mixer board for a DRM-signal of approximately 50mV RMS.

This is how a typical DRM signal looks like:





- Connect the decoder software to the 12 kHz IF output of the converter.
- Set the input volume of your PC properly.
- Set your FRG-100 to CW/N mode.
- Tune to a good DRM signal (3995,5955,6095,13810Khz...).
...Note: I have found that by tuning +/- 2Kc of the DRM signal, the quality improves. Possible reason could be the sound card timing accuracy, or the LO frequency is not exact. Experiment!
...Note: To decode a DRM signal, the signal strength needs to be high and the S/N ratio has to be at least above 12dB
- Once you here the software decoding the DRM-signal you can further tweak the settings as explained above. And, the software itself has several settings that can improve the reception/decoding capabilities.

Some examples of decoded DRM signals using this converter/mixer and a Yaesu FRG100

- **Example 1a of a decoded DRM signal** - ideal reception conditions!
- **Example 1b of a decoded DRM signal** - medium ideal reception conditions!
- **Example 2 of a decoded DRM signal** - medium ideal reception conditions!
- **Example 3 of a decoded DRM signal** - bad reception conditions!

Software

DRM

Dream
http://drm.sourceforge.net
Dream - to decode DRM signals: Dream v1.16 compiled version

...The necessary Qt runtime library "qt-mt230nc.dll" can be downloaded at:
...http://prdownloads.sourceforge.net/netclipboard/qt-mt230nc.dll?download

...Optional download: AMSchedule.ini
...Get the current shortwave broadcasting schedule for AM stations from:
...http://drm.sourceforge.net/download/AMSchedule.zip

Other DRM software: http://home.arcor.de/carsten.knuetter/drm.htm
SoDiRa
..Free Software Radio (also good for DRM)
..Tip: choose in Config->Receiver->Type: DSR30
..http://www.dsp4swls.de/sodira/sodiraeng.html

WinRadio
..Commercial DRM Demodulator/Decoder for Windows 2000, XP and Vista
..Tip: Choose general-purpose DRM Software Radio (DRM demodulator/decoder for third-party receivers)
..http://www.winradio.com/home/download-drm-2.htm

SDR

H**MDSR**
HMDSR is a powerful and free SDR capabale package.
Hhomepage

H**HDSDR Homepage**:
..HDSDR is a freeware Software Defined Radio (SDR) program for Microsoft Windows 2000/XP/Vista/7/8.
..download
..*Typical applications are Radio listening, Ham Radio, SWL, Radio Astronomy, NDB-hunting and Spectrum analysis.*
..*HDSDR (former WinradHD) is an advanced version of Winrad, written by Alberto di Bene (I2PHD).*

..**SDRadio**:
..SSB, CW and AM demodulator: http://www.sdradio.eu/sdradio/
..*By I2PHD and IK2CZL, practic skin, made for für I/Q direct mixing concepts,*
..*demodulates also by set an offset of middle frequency*
..*to 12 kHz single IF very well. Can handle 40kHz+*

..**G8JCFSDR**:
..Software defined radio using MF: http://www.g8jcf.dyndns.org/g8jcfsdr/
..*By G8JCF, good AM, better SSB and CW demodulator, also software AGC.*
..*Several filter and noise reduction equipment. Also recorder mode supported.*
..http://www.g8jcf.dyndns.org/g8jcfsdr/

..**SM6LKM**:
..A Soundcard Based SAQ VLF Receiver:
..http://web.telia.com/~u33233109/saqrx/saqrx.html

..**SoDiRa**
..Free Software Radio (also good for DRM)
..http://www.dsp4swls.de/sodira/sodiraeng.html

..**SDRadio**
..I2PHD's SDRadio can be downloaded from here:
..http://www.sdradio.org/

..**IFDSP**
..IK2CZL's IFDSP can be downloaded from here:
..http://www.detomasi.it/en/project.html

DRM reception with the Yaesu FT-817

We use the optional CW or SSB Filter slot in the main unit. You must have this slot free (no optional filter) for using DRM on this radio.
The 455 KHz Signal for the DRM mixer can be easy taken from the first pin (from right) of J21 connector and connect the ground of cable to the second pin.
Now put a 455kc resonator between the first right pin of J20 and the first right pin of J21. Note:

You can use simular like used in the FRG-100 please see fig2.
If you do not have a 455kc resonator then a capacitor of +/- 120 pf will be do, but you loose the agc advantages.

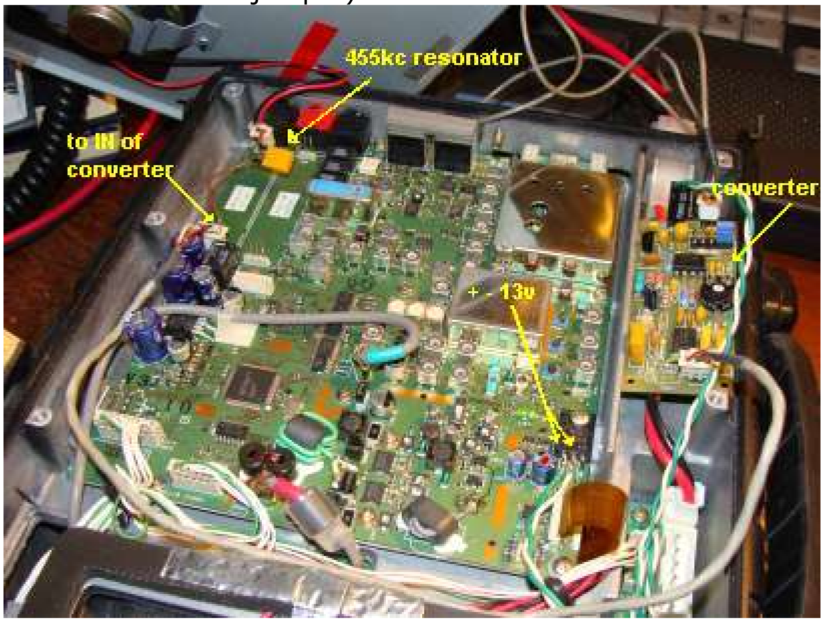
Switch on the rig and enter in the Menu System (press and hold the [F] key for on second) and choose Menu Item 38 [OP FILTER] setting mode CW.

You can activate now the DRM reception using the function NAR of the operation menu and setting CW MODE.

DRM reception with the Yaesu FT-897

Look for the slots for optional CW or SSB filter (backside, left) It's labelled: J24 and J23.
Bridge the left two pins of J24 – so the software will use this slot as if the SSB filter is installed.
Put a 455kc resonator between the right pin of J24 and the right pin of J23. The third pin of J23 is connected to ground.
If you do not have a 455kc resonator then a capacitor of +/- 120 pf will be do, but you loose the agc advantages

Connect the DRM converter to the two right pins of J23 (ground and 455 kHz IF in).
I tapped 13 volts from the 8 volt voltage regulator (see on photo lower right corner). This connection is in consistency with the power on/off state of the rig.
For using the converter you have to enable the 2.3 kHz optional Filter setting in Menu (that's the reason for the J24 jumper)



drm using a FT-897

Tips

* This converter can also be used to feed a LF-amplifier (listen to signals unfiltered)
* Works with some software defined radio (SDR) programs, like SDRadio from I2PHD!
* Use it to analyse wide band spectrum
* Modify the converter to allow even wider bandwidth by changing the resonating ceramic filter.
* Can of course be used by any receiver that has a 455kHz MF you can tap.

More about the SA602 (NE602,SA612,NE612,SA162) in this project

The SA602A is a Gilbert cell, an oscillator/buffer, and a temperature compensated bias network as shown in the equivalent circuit. The Gilbert cell is a differential amplifier (Pins 1 and 2) which

drives a balanced switching cell. The differential input stage provides gain and determines the noise figure and signal handling performance of the system.
The SA602A is designed for optimum low power performance. When used with the SA604 as a 45MHz cellular radio second IF and demodulator, the SA602A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -13dBm (that is approximately +5dBm output intercept because of the RF gain).
Besides excellent low power performance well into VHF, the SA602A is designed to be flexible. The input, RF mixer output and oscillator ports can support a variety of configurations provided the designer understands certain constraints, which are explained here.

[50Mc converter de ON6MU]
[SDRadio]
[FRG-100 audio improvement]
[Dream v1.16 compiled version]
[Example of a decoded DRM signal]

Technical graphs:

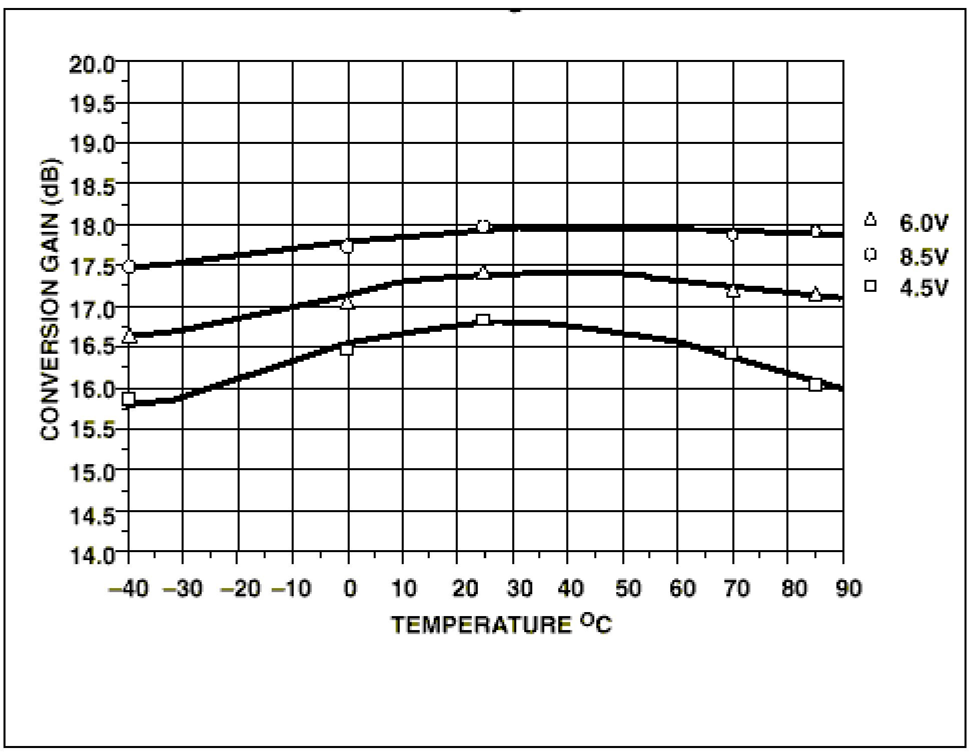


Figure 3 . Conversion Gain vs Supply Voltage

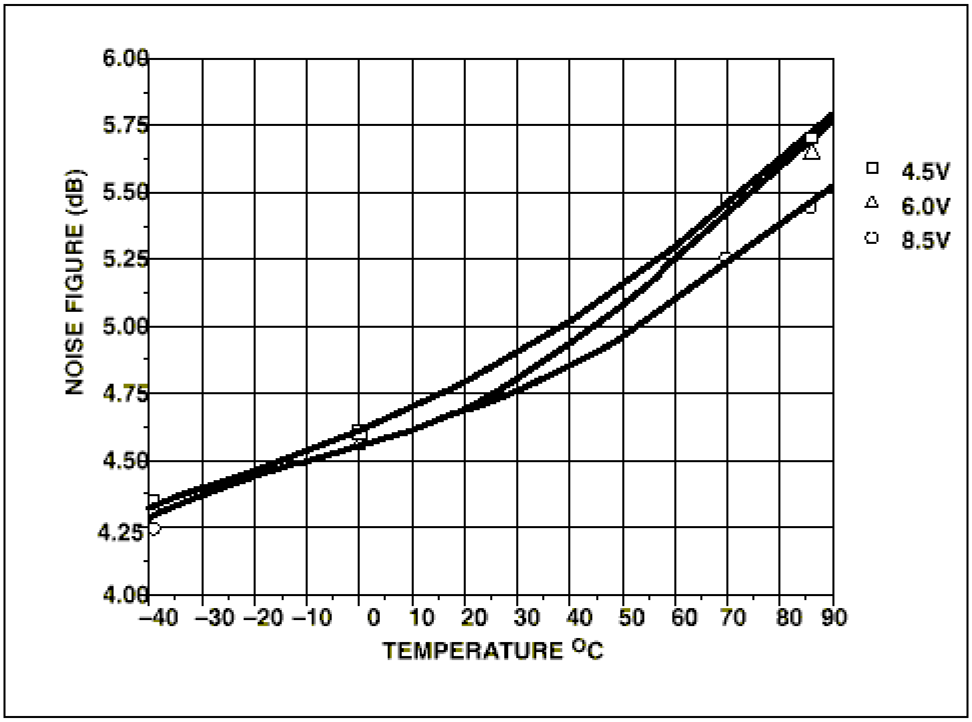


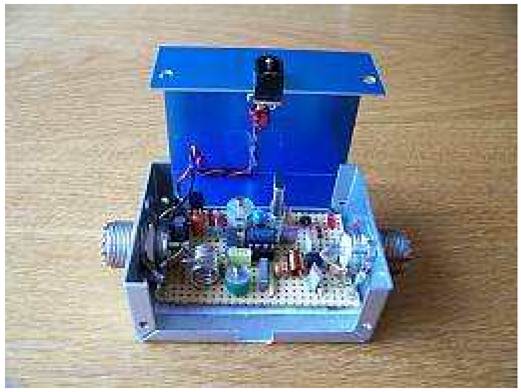
Figure 5. Noise Figure

Please also look at our Digital Analog Demodulation Project (DADP, VE7DXW) that explains in high detail how to use it for the Yaesu FT-817 and simular transceivers

More about these mods:

- 50Mc converter de ON6MU
- SDRadio
- FRG-100 audio improvement
- Dream v1.16 compiled version
- Example of a decoded DRM signal
- Ham mods modifications

Youtube:
This is how Tonino IZ6QTX made it and how he is using it:
http://www.youtube.com/watch?v=VoKhKqP2duM
http://www.youtube.com/watch?v=5MvFH9X5kpU
Thank you Tonino!



Please take a look at my 50MHz converter which is ALSO based on the SA/NE 602 mixer!

50 MHz converter, 6 meter, 6-meter, 50Mc, antenna, radio amateur. Use a beam and receive distant VHF signals! using NE602 home made

---

My E-mail

Note: if you want to commercialise, publish or distribute this project then you need to ask permission to do so.

Attention! The modification will be done at your own risk!

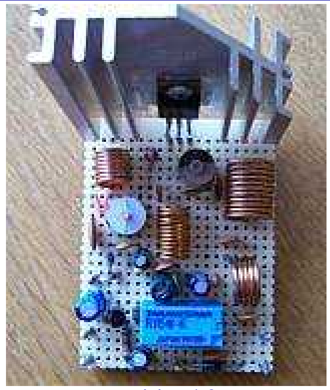
[home]

[mail] [shack] [homebrew] [software] [satellite]
[haminfo] [mods]

Back to ON6MU **Homepage**

ON6MU

Allmode RF Power Amplifier
for the HF 15 and 17 meterband (21Mc/18Mc)
RE-PA10HF17 and RE-PA10HF17



revision 1.3

By Guy, de ON6MU

About the 15- and 17-meterband HF amplifiers

This project and your efforts will provide you with a 0.55...3 watt input to easily 10 watt output. The two linear amplifiers are ment for use with QRP SSB/CW/FM/AM transmitters on the amateur bands 15 and 17 meters can be powered from a 12 volt DC supply. The design is a good balance between output power, physical size. The completed amplifier will reward the builder with a clean, more powerful output signal for a QRP rig when radio conditions become marginal. It has a RF-sensing circuit (Q2) wich allows the amplifier to switch on automatically when transmitting. This project uses a "classic" RF transistor. MOSFET power amplifiers are discussed and build in the near future on this website.

Bias
Power amplifiers used in base stations require biasing for proper RF performance. BIAS has be applied to Q1 to have clean proper and correct SSB modulation using this amplifier. Set P1 so +/- 35 mA current flows through Q1. Depending on the type of transistor this can vary somewhat, although you should never exceed 60mA! You don't need SSB? Read next part.

CW/AM/FM only
If you only want to amplify AM/FM/CW/FSK type of modulation (NOT SSB) then you can leave out the BIAS section for Q1 (between b1 and b2 in the schematic). You simply connect connection b2 to the ground, hence leaving out the somewhat critical setting of the correct BIAS for operating clean SSB.

Modulation modes
If using the schematic as displayed below and so also using Q1 BIAS, you can amplify any type of RF generated modulation waves.

Filter
RF purity and harmonic suppression is done here. Also allowing the transistor to be coupled to the antenna system through antenna impedance matching circuitry (C14). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands. This 4-element L-type narrow bandpass filter circuit and a 3 element low-pass PII filter for the desired frequency cleans out any remaining harmonic signals very efficiently.

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.

RF-sensing
The basic principle of RF-sensing using a relay is clearly drawn in the schematic and pretty much self explaining. Q2 (BC338, 2N2222) will conduct when RF energy is applied at the input of the amp (and so also via C18, D3, D5 biasing the base of Q2) hence powering up a RF capable relay. This relay switches between RX and TX with amp. When no Vcc is applied to our amplifier (and so Q2 too) no amplification is done. The input is simply re-directed directly to the output (as if your transceiver is connected without an amp). The RF sensing circuit is sensitive enough to react on .5 watt easily.
To allow the amplifier in SSB-modulation some extended PTT time-on the RF-sensing unit (Q2->relay) has to be increased. This is done by closing S1 (SSB/FM) and so C20 adds the needed "breathing" time. In FM/CW/AM/FSK modes a carrier is present and extended PTT time-on of the amplifier isn't needed, hence can be short.
Important: timing can vary on the type of relay used (Ohms resistance value of the relay coil), so often experimentation of C19 & C20 is needed.

An error in the schematic previous to rev. 1.3 connected the input of the rf-sensing circuit wrongly to C10, instead of the input PL259 connector IN.

Important: Everything will be within specs if you use RY5W relay, but timing (the "breathing time") can vary on the type of relay used (Ohms resistance value of the relay coil), hence experimentation of C31 is needed.

Note:
Although this example of RF-sensing isn't the Worlds most best sollution, it is pretty easy for beginners though. Better would be to drive t2 from your transceiver (amp drive) as this will switch at the very moment of PTT.

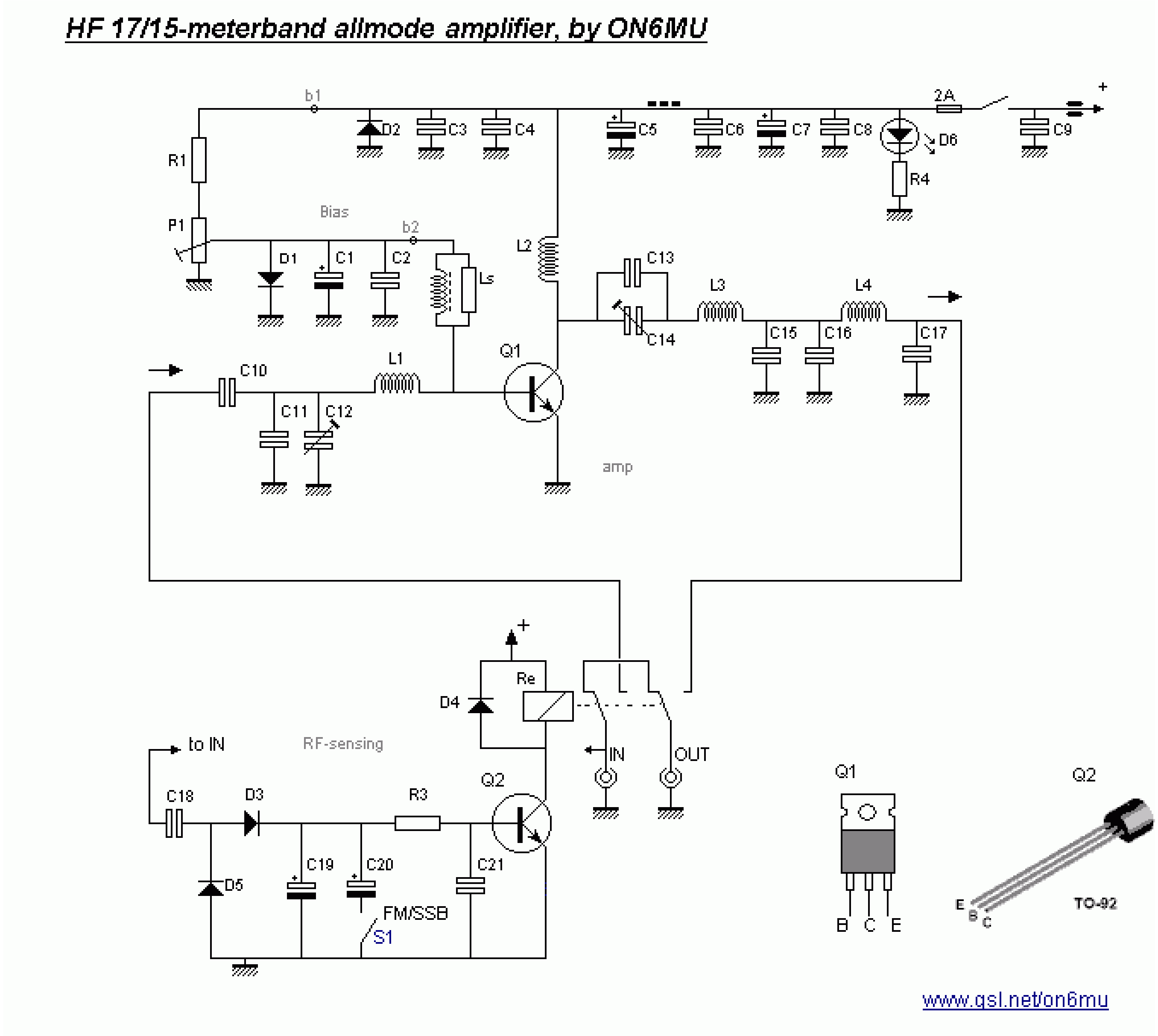
RE-PA10HF17: 17-meterband Amplifier settings

First set C12 and C14 to the middle and centre pin of P1 to the ground. After carefully mounting all parts and using as short as possible connections between the parts, gently add voltage to the amplifier while checking the current. The only current you should see is a the liddle idle current of Q1 (and LED D6 if connected). Increase the voltage to 12 volts. Check current again. It should (at this stage) be lower then +/- 20mA.

Now gently turn P1 till you get approx. 35 mA. Do not forget to mount Q1 on a heat sink isolated electrically from the transistor.

So far so good? Now we check if the (Q2) RF-sensing circuit is working properly. Connect a proper dummy load and a power meter to the output of the amp. Remove any connectors from your power supply and temporary disconnect the collector from the VCC. Connect your transceiver to the input. Be sure you set your tranceiver's power to minimum (never more then 3 watts) and you set your transceiver to 18.100Mc in CW/FM. Key your transceiver and if all goes well the Relay should power up and you should see the current rise and your power meter should already show an amplification of the RF input power.

Still all working as planned? Excellent! Now carefully turn C12 till you get maximum output power (whilest checking the input SWR on your transceiver or SWR meter). And finally tune C14 to maximum power. If needed re-tune C12 and C14 till you reached the maximum. Current should be around 1.2 Amp +/- (depending on the voltage and input power).

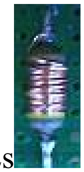


Parts list 17-meterband power amplifier

- Q1 2SC1969 (only Mitsubishi type!!), ERF-2030, 2SC1173, 2SC1944, 2SC2075
  (with proper heatsink isolated from the transistor)
  Note: There are reports I've read on various web sites about counterfeit components especially RF transistors, so be careful in buying huge lots. For example: I know that the 2sc2075 marked with a T works while others not?!
- Q2 BC338, BC337, 2N2222
- C1 1uF/25v
- C2 22nF
- C3 10nF
- C4 560pF
- C5 22uF/25v
- C6 47nF

- C7 100uF/25v
- C8 1nF
- C9 100nF
- C10 68pF
- C11 180pF
  (Stan 9H1LO reported using a 270pF instead of 120pF (rev1.2c 180pF) prevented the amp from oscillating in 24mc, probably do to differences in transistors and PCB)
  (Peter DL6NL reported using a 200pF which allowed 1:1 SWR)
- C12 6...40pF set at half position and tune to max power and best input SWR
- C13 68pF
- C14 6...40pF set at half position and tune to max power on 50 Ohm dummyload
- C15 120pF
- C16 47pF
- C17 180pF
- C18 10pF
- C19 2.2uF/25v
- C20 68uF/25v
- C21 100nF
- R1 1k5 (revision 1.2)
- R3 1k5
- R4 1k
- P1 5k (revision 1.2) pot. to set BIAS for correct SSB operation +/- 35mA@13.8v
- D1 1N4148 (revision 1.2)
- D2 1A si diode 1N4001, 1N4005
- D3,D4,D5 1N4148
- D6 LED
- Re = 12volt relay with silver plated contacts and low RF capacitance with 2times 3pole switch: RY12W-K
- L1 = 1mm Cul (insulated copper wire), 7 turns close together, 7mm inside diameter
- L2 = 0.6mm Cul (insulated copper wire), 14 turns 0.5mm space, 7mm inside diameter
- L3 = 1mm Cul (insulated copper wire), 11 turns close together, 10mm inside diameter
- L4 = 1mm Cul (insulated copper wire), 5 turns close together, 10mm inside diameter

- Ls = 470 1/2 watt carbon, 0,2 Cul turned 3 times over the entire length of the resistor
- Ferrite bead 3 turns wire inside
- S1 switch open = AM/CW/FM/PSK/PKT, switch closed = SSB

Ls

Note:
Always use a dummy load for testing and adjusting the amplifier!!!

Specifications RE-PA10HF17

- Peak Frequency range: 18Mc...18.5Mc
- Output RF power: at least 8W @ 13.8v - 12W@16v
- All modulation modes
- Adjustable output impedance to 50 Ohms
- Adjustable input impedance to 50 Ohms
- High efficient band-pass type harmonic L-filter + lowpass PII filter
- PII-filter at input
- Usable voltages: Vcc 10 - 18 volts
- Average current I: +/- 1A @ 14 v
- RF-sensing
- VSWR overload resistant (not infinite)
- Can be used without complex BIAS if only needed for CW/AM/FM/FSK type modulation

How **Peter DL6NL** made it!
Click image to enlarge

RF Power transistors:

2SC1969/ERF-2030

Features:

- High Power Gain: G_{pe} >/= 12dB (V_{CC} = 12V, P_O = 16W, f = 27MHz)
- Ability to Withstand Infinite VSWR Load when Operated at:
  V_{CC} = 16V, P_O = 20W, f = 27MHz

Application:

- 10 to 14 Watt Output Power Class AB Amplifier Applications in HF Band

Absolute Maximum Ratings: (T_C = +25°C unless otherwise specified)

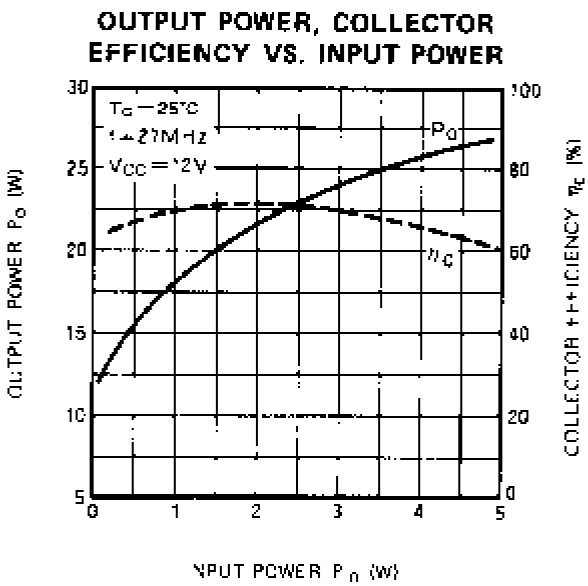
Collector-Emitter Voltage (R_{BE} = Infinity), V_{CEO}	25V
Collector-Base Voltage, V_{CBO}	60V
Emitter-Base Voltage, V_{EBO}	5V
Collector Current, I_C	6A
Collector Power Dissipation (T_A = +25°C), P_D	1.7W
Collector Power Dissipation (T_C = +50°C), P_D	20W
Operating Junction Temperature, T_J	+150°C
Storage Temperature Range, T_{stg}	-55° to +150°C
Thermal Resistance, Junction-to-Case, R_{thJC}	6.25°C/W
Thermal Resistance, Junction-to-Ambient, R_{thJA}	73.5°C/W

Electrical Characteristics: (T_C = +25°C unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	I_C = 1mA, I_E = 0	60	-	-	V
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	I_C = 10mA, R_{BE} = Infinity	25	-	-	V
Emitter-Base Breakdown Voltage	$V_{(BR)EBO}$	I_E = 5mA, I_C = 0	5	-	-	V
Collector Cutoff Current	I_{CBO}	V_{CB} = 30V I_E = 0	-	-	100	µA
Emitter Cutoff Current	I_{EBO}	V_{EB} = 4V, I_C = 0	-	-	100	µA
DC Forward Current Gain	h_{FE}	V_{CE} = 12V, I_C = 10mA, Note 1	10	50	180	
Power Output	P_O	V_{CC} = 12V, P_{in} = 1W, f = 27MHz	16	18	-	W

Collector Efficiency			60	70	-	%

Note 1. Pulse test: Pulse Width = 150µs, Duty Cycle = 5%.



ERF-2030 Features...

1/ The ERF-2030 is a 25 watt* transistor - therefore, it is not just a replacement part, but also an UPGRADE to the old Mitsubishi part.

2/ The ERF-2030 is NOT an "electrical drop in replacement" for the 2SC2166, 2SC1969 and 2SC2312. However, circuit modifications on most radio's are minimal and documentation is readily available for FREE.

3/The ERF-2030 is a "mechanical drop in replacement" for the 2SC2166, 2SC1969 and 2SC2312. This means that the The ERF-2030 features a TO-220 package with the SAME pinout configuration as the 2SC2166, 2SC1969 and 2SC2312. Therefore NO mechanical modifications to the ERF-2030 are necessary for most installations

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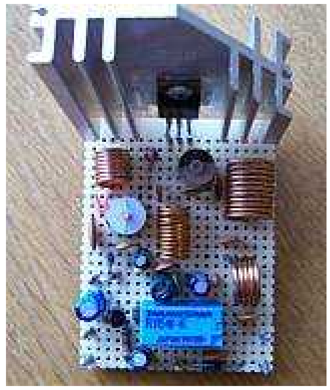
Allmode RF Power Amplifier for the 15 meterband (21Mc)
RE-PA10HF15



By Guy, de ON6MU

About the 15-meter band HF amplifier RE-PA10HF15

All is already explained above (17-meter band amplifier): Read it here

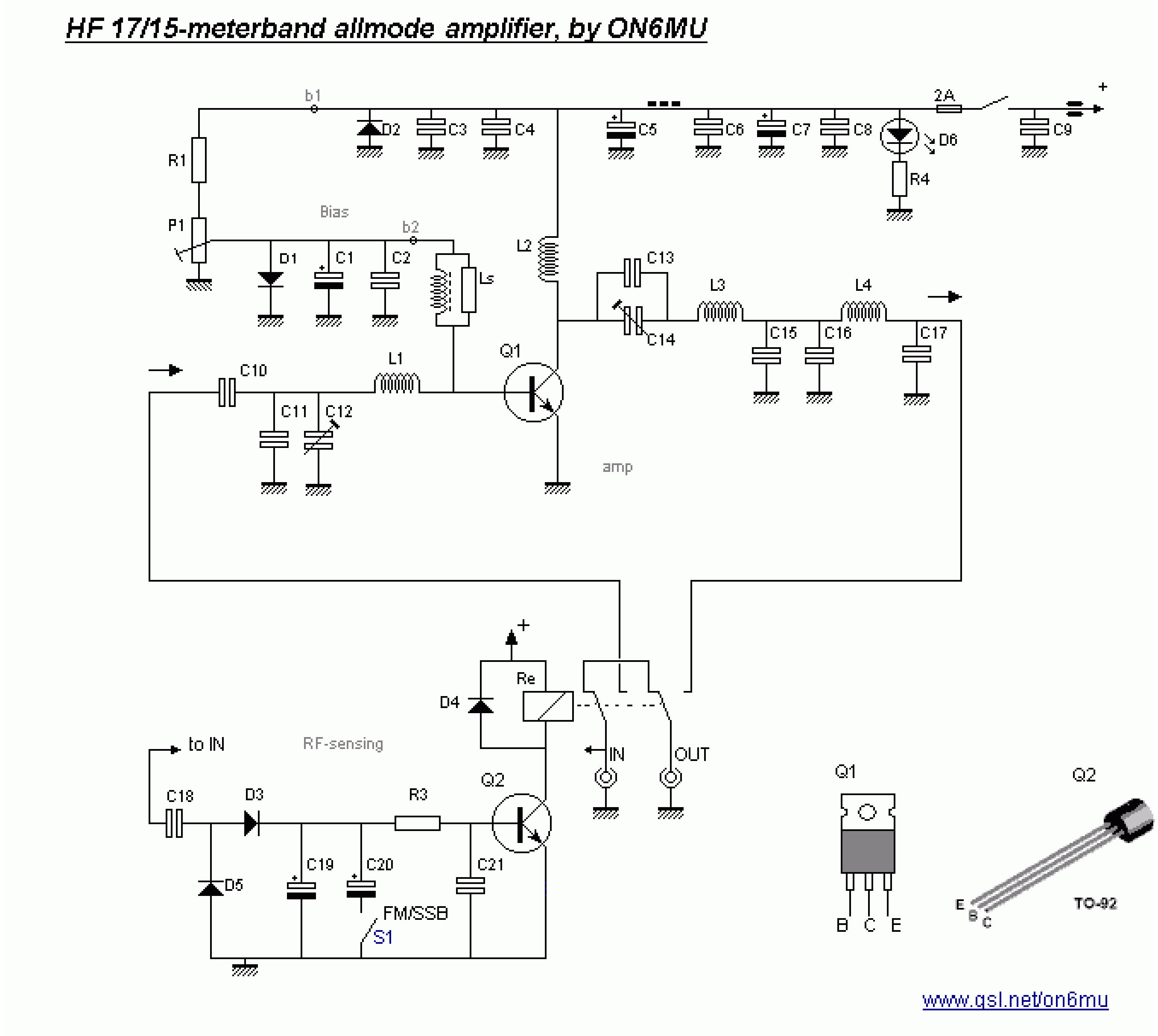
15-meterband Amplifier settings

First set C12 and C14 to the middle and centre pin of P1 to the ground. After carefully mounting all parts and using as short as possible connections between the parts, gently add voltage to the amplifier while checking the current. The only current you should see is a the liddle idle current of Q1 (and LED D6 if connected). Increase the voltage to 12 volts. Check current again. It should (at this stage) be lower then +/- 20mA.

Now gently turn P1 till you get approx. 35 mA. Do not forget to mount Q1 on a heat sink isolated but electrically from the transistor.

So far so good? Now we check if the RF-sensing circuit is working properly. Connect a proper dummy load and a power meter to the output of the amp. Remove any connectors from your power supply and temporary disconnect the collector from the VCC. Connect your transceiver to the input. Be sure you set your tranceiver's power to minimum (never more then 3 watts) and you set your transceiver to 21.200Mc in CW/FM. Key your transceiver and if all goes well the Relay should power up and you should see the current rise and your power meter should already show an amplification of the RF input power.

Still all working as planned? Excellent! Now carefully turn C12 till you get maximum output power (whilest checking the input SWR on your transceiver or SWR meter). And finally tune C14 to maximum power. If needed re-tune C12 and C14 till you reached the maximum. Current should be around 1.2 Amp +/- (depending on the voltage and input power).

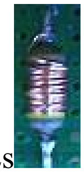


Parts list 15-meterband power amplifier RE-PA10HF15

- Q1 2SC1969 (only Mitsubishi type!!), 2SC1173, 2SC1944
  (with proper heatsink isolated from the transistor)
- Q2 BC338, 2N2222
- C1 1uF/25v
- C2 22nF
- C3 10nF
- C4 560pF
- C5 22uF/25v
- C6 47nF

- C7 100uF/25v
- C8 1nF
- C9 100nF
- C10 68pF
- C11 100pF *(If amp oscillates in higher frequencies do to transistor deviations or PCB coupling, try 180pF)*
- C12 6...40pF set at half position and tune to max power and best input SWR
- C13 56pF
- C14 6...40pF set at half position and tune to max power on 50 Ohm dummyload
- C15 100pF
- C16 47pF
- C17 150pF
- C18 8pF
- C19 2.2uF/25v
- C20 68uF/25v
- C21 100nF
- R1 1k5 (revision 1.2)
- R3 1k5
- R4 1k
- P1 5k (revision 1.2) pot. to set BIAS for correct SSB operation +/- 35mA@13.8v
- D1 1N4148 (revision 1.2)
- D2 1A si diode 1N4001, 1N4005
- D3,D4,D5 1N4148
- D6 LED
- Re = 12volt relay with silver plated contacts and low RF capacitance with 2times 3pole switch: RY12W-K
- L1 = 1mm Cul (insulated copper wire), 6.5 turns close together, 7mm inside diameter
- L2 = 0.6mm Cul (insulated copper wire), 12 turns 0.5mm space, 7mm inside diameter
- L3 = 1mm Cul (insulated copper wire), 11 turns close together, 10mm inside diameter
- L4 = 1mm Cul (insulated copper wire), 4.5 turns close together, 10mm inside diameter
- Ls = 470 1/2 watt carbon, 0,2 Cul turned 3 times over the entire length of the resistor

- Ferrite bead 3 turns wire inside
- S1 switch open = AM/CW/FM/PSK/PKT, switch closed = SSB

Ls 

Note:
Always use a dummy load for testing and adjusting the amplifier!!!

Specifications

- Peak Frequency range: 21Mc...21.5Mc
- Output RF power: at least 8W @ 13.8v - 12W@16v
- All modulation modes
- Adjustable output impedance to 50 Ohms
- Adjustable input impedance to 50 Ohms
- High efficient band-pass type harmonic L-filter + lowpass PII filter
- PII-filter at input
- Usable voltages: Vcc 10 - 18 volts
- Average current I: +/- 1A @ 14 v
- RF-sensing
- VSWR overload resistant (not infinite)
- Can be used without complex BIAS if only needed for CW/AM/FM/FSK type modulation

Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...). Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your antenna is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is equally important to be able to make DX QSO's.

Related

Remember that transmitting and/or using an power levels higher then your local license permit is illegal without a valid radioamateur license!

Another related project:[1watt 10 meterband transmitter project]

ON6MU
Home

ON6MU's "Vipormutant" Antenna
RE-AHFV14P

Versatile Inexpensive Portable Multi-band Tunable Antenna

de ON6MU
revision 2

Features

- Only 3 meters high fully extended (effective radiating element height)
- Less then one meter inserted (no element is larger then one meter including the tunable section)
- Tunable without the use of an extra tuner (just switch till you get the best SWR)
- Covers all frequencies from UHF to 7 MHz without a tuner
- UHF (tuned by de- or increasing the length of the antenna) 3/4 2*5/8 4*5/8
- VHF (tuned by de- or increasing the length of the antenna) 1/4 5/8 2*5/8
- HF (tuned by switching)
  6 meters (1/4 1/2)
  10 meters (1/4)
  12 meters
  15 meters

17 meters
20 meters
30 meters
40 meters: with large counterpoise and/or with longer radiating element, or extra tuner
80 meters: if radiating element is > 5 meters, or with large counterpoise and/or with extra tuner

- Works with or without cointerpoise
- Ideal as portable or balcony antenna
- Compact and extremly portable
- Not too critical on the material or sizes of the elements
- +- 50 watt input
- SWL's Note: tunable on all frequencies between the bands mentioned above

What you need to build the "Vipormutant"

- 5 (or more depending on how high you want your boom) alu tubes
- piece of hard insulating tube (+- 7 cm), examples: plastic, nylon, bamboo...
- some low loss RG174 50 Ohm coax
- carbon/ferrite bead or toroid (to act as a choke)
- a few meters of 0,75mm enamelled copper wire to make the coil
- SO239 (PL259 female)
- Paint, silicon, glue etc. to seal things up
- Plastic box to mount over the coil and where we'll put the switch and SO239 connector
- 12 position rotary switch
- a few innox hose clamps

About the "Vipormutant" antenna:

Well yes, one must have a name HI...It is nothing more then a base coil loaded antenna, but with a selector direct on the base to tune the antenna.
Most of us don't have the luxury of building a 1/4, 1/2 or even a 5/8 wavelength vertical antenna for HF. We have to settle for something a little shorter. (A lot shorter, in the case of people following the FCC's Part 15 rules, which limit them to 3 meters in size.) Shorter vertical antennas can give acceptable (but not spectacular) performance.
I needed a highly (HF) portable antenna to use with my FT-817 which should have the highest possible frequency range (also VHF) and still compact enough to take along almost anywhere! The antenna should be versatile enough to allow further experimenting, to allow being mounted on a balcony, caravan, outdoors etc... So I came up with a compact vertical (dismounted no higher then 1 meter) with a "tuner" directly connected to the antenna radiating element (the best possible place a tuner can be).
The "Vipormutant" tuning principle gets energy into the antenna on a wide range of frequencies, but the design of an antenna is what controls what happens to the RF energy from there. For some antennas, the antenna is simply not complete without a radial system, or at least a counterpoise. Other types of antennas need no RF ground system at all. Most reference books on antennas provide solid guidance on radials and counterpoises, but only for antennas cut to a specific frequency. When using the "Vipormutant" it will also act like tuner and at the best place a tuner should be: directly beneeth the antenna! So the rules have to change somewhat because the "Vipormutant" almost operates across the full range of HF frequencies unto UHF. It doesn't need a counterpoise to work, but the efficiency will increase when you do use it.

Considerations:

- If the length of the conductor is very short compared to a wavelength (< wave/4), the electric and magnetic fields will decrease dramatically within a distance of one or two wavelengths.
- It is impossible to make a small antenna to radiate as efficient like a big antenna.
- Ground losses affect radiation patterns and cause high signal losses for some frequencies. Such losses can be greatly reduced if a good conducting ground is provided in the vicinity of the antenna.

The coil/tuner

Wind 0,8mm enamelled copper wire around the isolator (+- 16mm diamter) and make a tap every xx turns (see fig. 2 and 3)

Fig.1

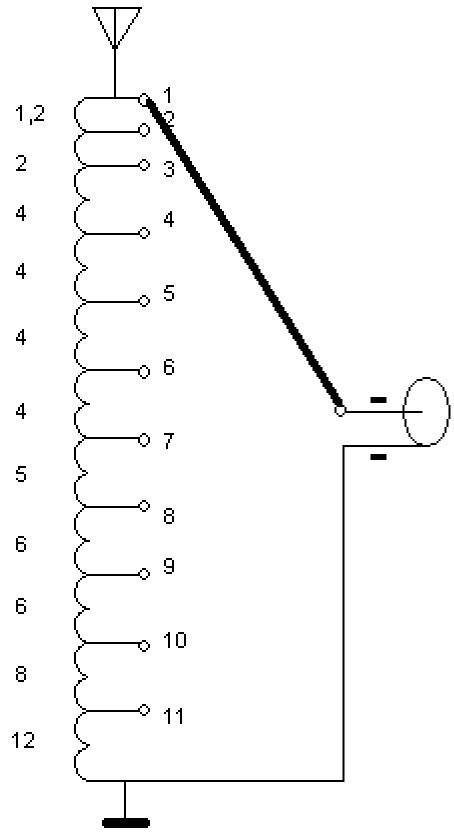


Fig.2  The coil dimensions isn't too critical.

Relatively short antennas behave like lossy capacitors and present a high impedance load to the transmitter due to the large amount of capacitive reactance that is present. The loading coil helps to tune out that reactance. Tuning out the reactance is important because a tuned antenna will accept and radiate much more power than a mismatched antenna.

When the loading coil is installed at the bottom of the vertical radiator, we call it a "base loaded" antenna. Base loading requires the smallest amount of inductance to achieve resonance.

The shoke

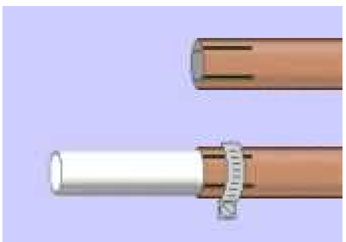
Is made out of miniature 50 Ohm coax (rg174) that goes a few turns through the carbon/ferrite bead or toroid. You can also use a Snap-Together Ferrite Choke Core.
If a ferrite is put over a cable which includes both signal and return lines, it will have no effect on the signal (differential-mode) current but it will increase the impedance to common-mode currents. This is because the differential currents, by definition, sum to zero in each wire pair and therefore there is no net magnetic field. If there is no field, the ferrite is invisible. But the common mode currents do produce a net magnetic flux and this flux is concentrated in the bulk of the ferrite, leading to an increased impedance for these currents only. The choke should prevent any mantle currents flowing and should decrease RFI.

The effectiveness can be increased by looping the cable several times through the core, but the benefit is limited at higher frequencies by the stray capacitance between the turns of the cable.

Fig 3.

4 turns

The base insulator

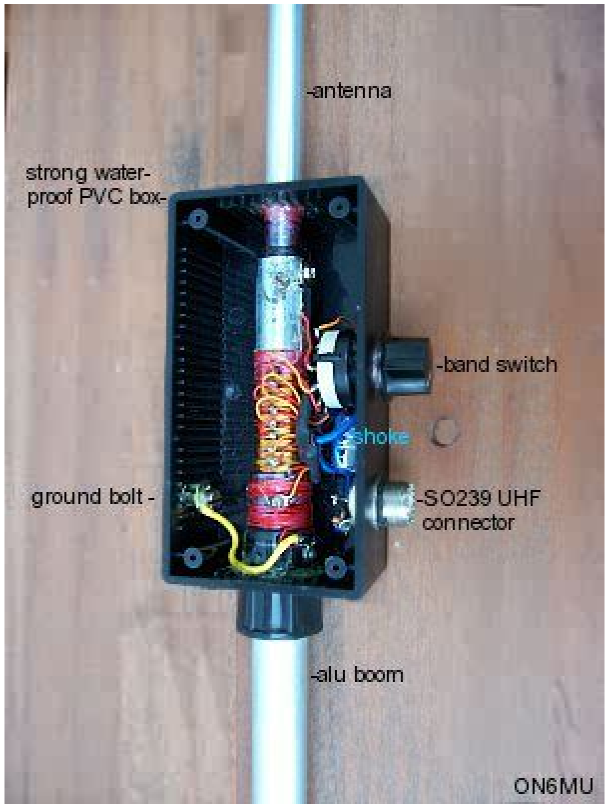


The vertical radiator "driver" element and tuning box

I used a plastic box of 130x70x40mm. On top and bottom I drilled a hole to fit the driver element (radiator of +/- 40cm length)and boom (also +/- 40cm length).
On the side I drilled a hole for the rotary switch and the SO239 connector, whilest on the opposite side I drilled a hole to fit a "ground" bolt where I can easily connect the counterpoise and/or ground to if needed.

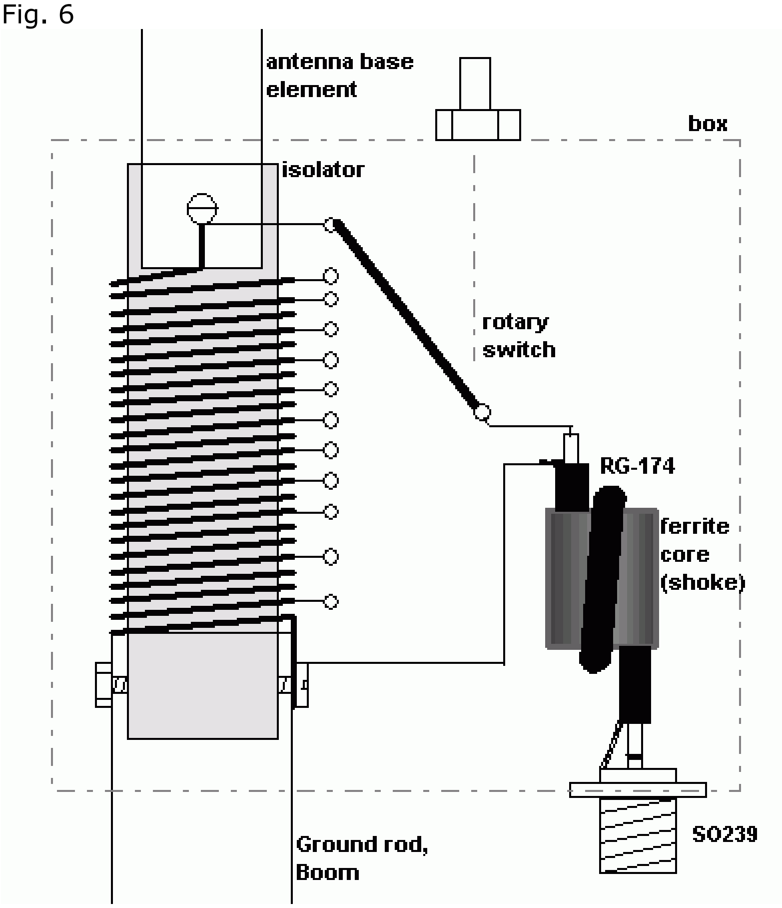
Fig 4

Fig 5



This is how things are connected inside the box:

Fig. 6



Example

The rotary switch is used for tuning the antenna on each band. The first position allows UHF/VHF ranges.
Tuning is done by sliding in/out of the elements.
The "lower" the switch (higher inductance) the lower the resonance frequency of the antenna.

Remember, and this is important too, to seal everything up so no moisture can penetrate the antenna!
Because the radiating vertical antenna elements are made out of separate pieces that fits inside each other and are tightened by hose clamps, the construction isn't waterproof.
If you use a hollow isolating piece you need to to prevent moisture from getting inside the box (via the places where the elements are hold together). I've used a rubber "stopper" that fits snugly on the bottom of the driver element and glued tight.

Black paint finishes the job:

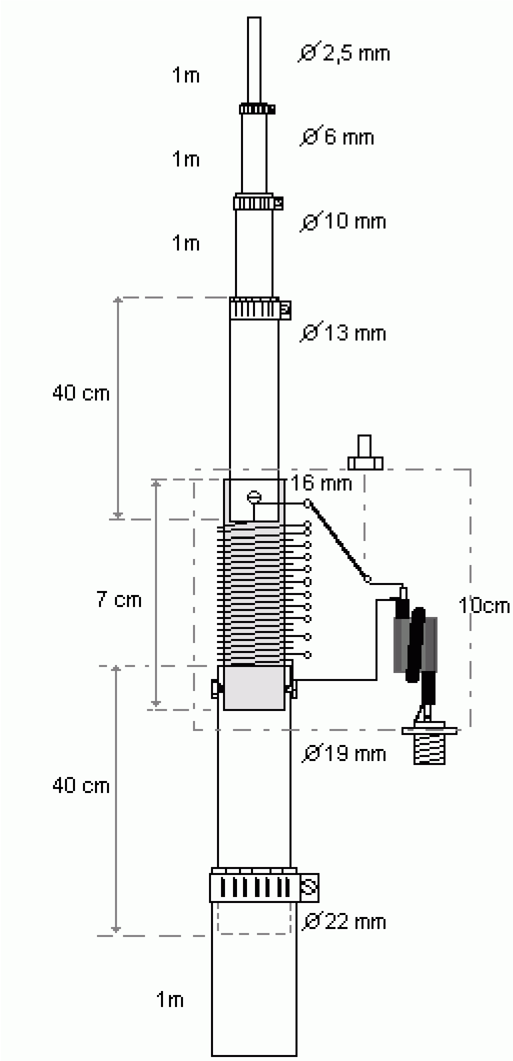
fig. 7
 using a round box
In my first design I used a plastic box of 50mm diameter and 9 cm heigh. On top I drilled two holes: one for the driver element (radiator of 40cm) and a hole for the rotary switch (as was used in the first prototype).

fig.8: The main driver element and tuning unit finished


This allows it to be used on almost any boom or can be extended to use with or without vertical elements! Ideal for experimenting!

The antenna construction specs

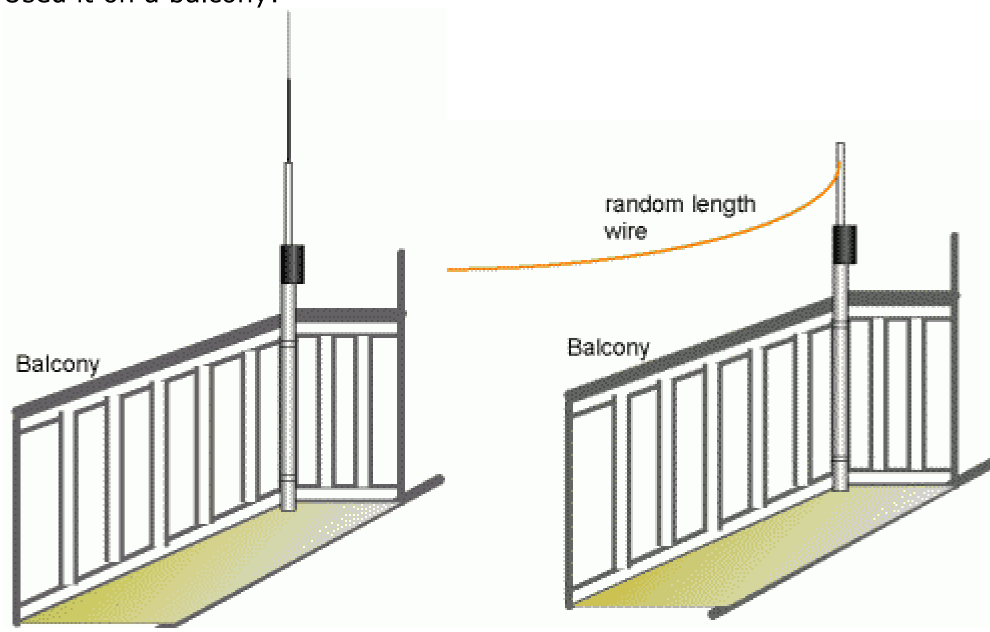
All elements are made out of aluminum.
Fig. 9



This makes the antenna effective radiating elements a total length of 3 meters. The boom elements can be chosen freely and on your needs. A short one (one element of a meter), a medium sized one of several 1 meter tubes or none at all! The bottom piece where the boom is "connected" too is 40 cm and can/could be put directly in the ground (if made pointed for sure). Or you could fix it in a umbrella stand. Use your imagination HI.

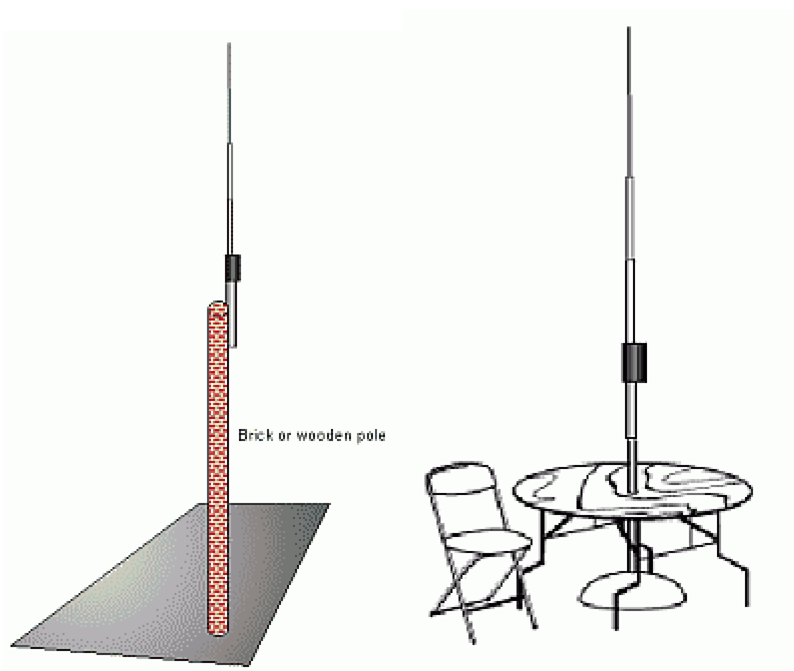
Examples of "Vipormutant's" utilization

Used it on a balcony:



This could cover even the lowest HF-bands!

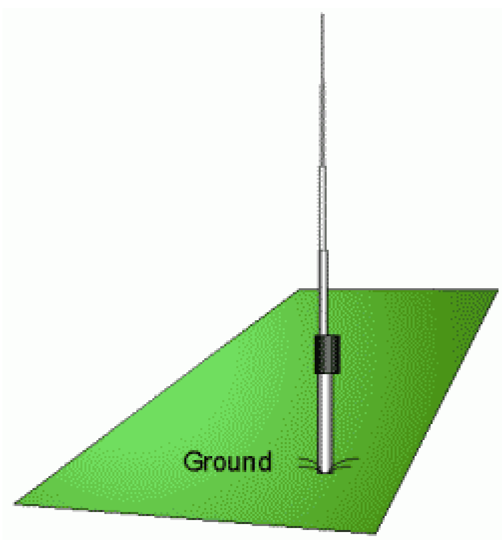
Use it outdoors without grounding:

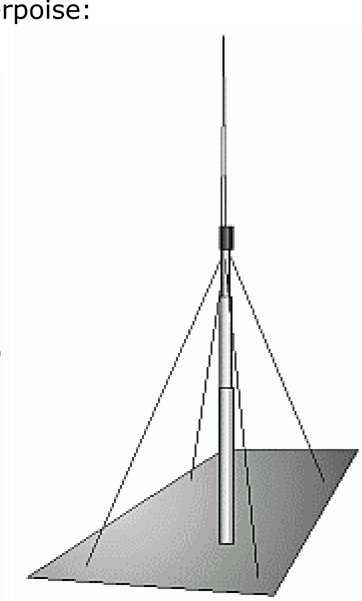


Use it outdoors as a shortened "dipole" balanced antenna
(rotary switch set approx. in the middle):

Frequencies below 7 MHz could easily be match 1:1 SWR if total length of the "dipole" > 4 meters
Further tuning can be done with selecting a different impedance using the rotary switch.
Different lengths of wire can be used (an example: one part 3 meter, the other 5 meter or more)

Use it outdoors with ground or counterpoise:





Radials and Counterpoises basic purposes:

1. To improve the RF ground conductivity for the ground current return path. Unless you live in a salt-water swamp, your ground conductivity makes a very poor path for the return of ground currents. This increases the ground losses and reduces the efficiency of an antenna that needs a good RF ground.

2. To provide a counterbalance for the feed point of the antenna to reduce RF radiation back to the radio room. The "Vipormutant" changes the rules because there is no single frequency that you will be operating on, so all of the thumb rules for 1/4 and 1/2 wavelength radials don’t apply. It is possible to be either a purist or a pragmatist in deciding what radials to put in place.

3. Number of radials: More is better, up to a point. In carefully controlled experiments, it has been proved that increasing the number of radials from 2 to 15, or from 4 to 16, produces significant increases in signal strength. Further increasing the number of radials to 60 only produces 1 to 2 dB of increase in field strength. Follow this link to see some of the empirical data.

4. Where to put the radials: For a semi-permanent installation, it is customary to bury the radials a few inches down in the soil. This makes it much easier to mow and walk in the area around the antenna. However, some experimenters have gotten an improvement in performance by raising the radials and the antenna base a few inches above the soil. Raising the antenna and ground system several meters above the earth, for example by installing the base of the antenna on a roof-top, can improve the antenna's performance by reducing capacitive earth losses.

While the "Vipormutant" will provide a good match with a poor RF ground system which will will able you to transmit, your antenna efficiency will be low. Nevertheless, by using a tuning circuit directly at the antenna

radiating element losses are kept to a miminum. Getting the greatest efficiency out of your antenna system needs a proper RF ground unless you're using a balanced antenna system

The efficiency of the antenna increases by using a counterpoise. However, the antenna can be tuned perfectly without!

Don't forget to check these out:

.**ON6MU Homebrew projects**
.Radioamateur related projects

.**ON6MU Ham mods**
.Modifications of transceivers

73"

Have fun and my best 73"

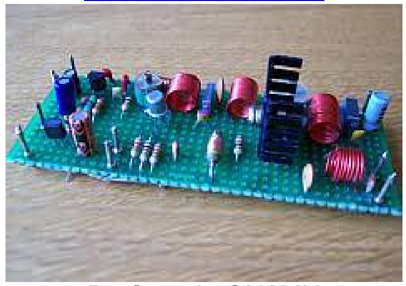
Guy, ON6MU
http://www.qsl.net/on6mu

Comments, pictures or experiences with my antenna are always welcome!

ON6MU

ON6MU

1Watt AM(cw) Transmitter
for the 10 meterband
RE-TX1HF10



By Guy, de ON6MU
Revision v1.6 (Jan 2012)

About the 1watt AM/CW 10-meter band transmitter RE-TX1HF10

In this project, you will make a simple 3-stage low-power broadcast-type circuit, using a crystal oscillator integrated circuit and an a collector modulated AM oscillator with amplifier. You can connect the circuit to the an electred microphone or amplified dynamic microphone. Using an electred microphone is shown (in gray) in the diagram below. (no amplified dynamic microphone has a to low output voltage to work. at least 100mv is needed). You could also add a LF preamp stage of one transistor to allow connecting a dynamic microphone directly.

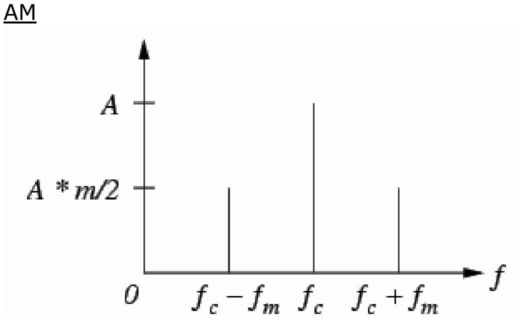
You'll see that you can receive the signal through the air with almost any AM radio receiver. Although the circuits used in radio stations for AM receiving are far more complicated, this nevertheless gives a basic idea of the concept behind a principle transmitter. Plus it is a lot of fun when you actually have it working!
Remember that transmitting on the 10 meter band you'll need a valid radioamateur license!!

A wide range of different circuits have been used for AM, but one of the simplest circuits uses collector modulation applied via (for example) a transformer, while it is perfectly possible to create good designs using solid-state electronics as I applied here (T1 BC557).

The transmitter is build as a Colpitts Oscillator with a BSX20 transistor. HF-output of the oscillator is approx. 50 mW, depending on the supply voltage of 8 to 16 Volts. This is amplified by the BD135 and brings the power up to approx. 1 watt @ 14volts with 100% modumation. The transmit frequency is stabilized with the 28Mhz crystal. A slight detuning of approx 1kc is possible when using a 120pF trimmer capacitor for C8. The oscillator signal is taken from the collector of T2 and guided to the input of T3 which output is lead via an L-filter and low-pass PII filter circuit cleaning up the signal pretty good and ensuring spectral purity. The oscillator is keyed by T1 and the morse key (S). By keying the morse-key T1 is not been used for modulation and is biased, hence lets T2 freely oscillate.

The oscillator uses a single coil and crystal. The coil is tuned to the output frequency, which may correspond to the crystal frequency, or a harmonic.

AM



The resulting AM spectrum using sinusoidal carrier and modulating waveforms.

Amplitude Modulation (AM) is a process in which the amplitude of a radio frequency current is made to vary and modify by impressing an audio frequency current on it.
This was the first type of modulation used for communicating signals from one point to another and is still the simplest to

understand.
A radio frequency current has a constant amplitude in absence of modulation and this constant amplitude RF carries no information, i.e. no audio intelligence and is of no use to radio telephone (voice communication), but has application in morse code communication.
In its basic form, amplitude modulation produces a signal with power concentrated at the carrier frequency and in two adjacent sidebands. Each sideband is equal in bandwidth to that of the modulating signal and is a mirror image of the other. Thus, most of the power output by an AM transmitter is effectively wasted: half the power is concentrated at the carrier frequency, which carries no useful information (beyond the fact that a signal is present); the remaining power is split between two identical sidebands, only one of which is needed.

CW
CW is the simplest form of modulation. The output of the transmitter is switched on and off, typically to form the characters of the Morse code.
CW transmitters are simple and inexpensive, and the transmitted CW signal doesn't occupy much frequency space (usually less than 500 Hz). However, the CW signals will be difficult to hear on a normal receiver; you'll just hear the faint quieting of the background noise as the CW signals are transmitted. To overcome this problem, shortwave and ham radio receivers include a beat frequency oscillator (BFO) circuit. The BFO circuit produces an internally-generated second carrier that "beats" against the received CW signal, producing a tone that turns on and off in step with the received CW signal. This is how Morse code signals are received on shortwave.

Although this design is primarely designed for AM, it can be used for CW by keying S and so powering the oscillator. You can remove the modulation section all together if you use it only for CW. The amplifier (T3) is always fed with 12...16 volts Vcc and doesn't need to be switch off together with the oscillator.

If you only gonna use this transmitter for CW, then you can leave out the modulater section (T1). But remember that there is a 3 volt difference between Vcc and the voltage on the oscillator. So with modulator 12 Vcc is 9 volts on T2, without T1 ofcourse 12v also.

RF Oscillator
Is been carried out by T2 (NPN BSX20). This is the stage where the carrier frequency intended to be used is generated by means of Crystal Oscillator Circuitry or capacitance-inductance based Variable Frequency Oscillator (VFO). The RF oscillator is designed to have frequency stability (Xtal) and power delivered from it is of little importance, although it delivers 50mW@14v , hence can be operated with low voltage power supply with no dissipation of heat.

You could add a switch (not recommended, but if you do, use very short connections) to select different Xtal's (frequencies). You could also use a more effective diode-based switch I've build here. This hasn't got the problems with longer connections at all.

Injection of signal of an external tuneable oscillator to trigger T2 to oscillate is possible by removing the Xtal and connecting C8 to your oscillator.

Filter
RF power amplification is also done here and this stage is coupled to the antenna system through antenna impedance matching circuitry (L1/L3,C16,C18). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands (L3/L4,C16...C20). This 3-element L-type narrow bandpass filter circuit and a lowpass filter for the desired frequency cleans out any remaining harmonic signals very efficiently.

Modulator
Is done by T1 (PNP BC557). Audio information is impressed upon the carrier frequency at this stage. Do to selective components circuits (R10, R11, C25, C3, C4, C5, C6, C7) the voice component frequencies are enhanced, whilest others are suppressed (bandwidth +- 3kc/side) keeping it approx. between HAM-radio specs.
Collector modulation is applied here. The efficiency isn't 100%, but it does keep the simplicity of the design intact.

Why over modulation is not desirable?..
Over modulation is not desirable, i.e. modulation should not exceed 100 %, because if modulation exceeds 100 % there is an interval during the audio cycle when the RF carrier is removed completely from the air thus producing distortion in the transmission.

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.

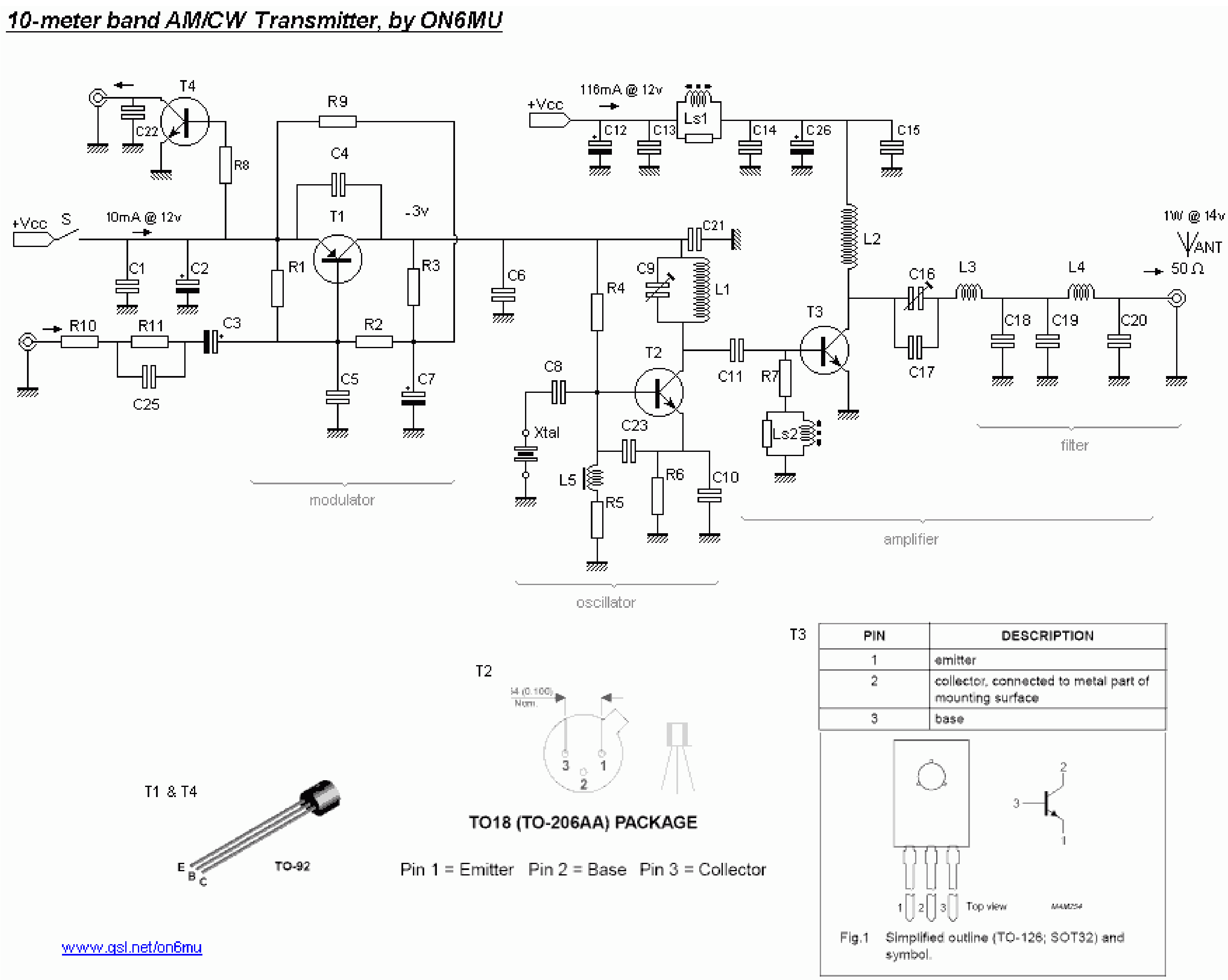
More power
You can connect the output to my power MOSFET based 10-meterband power amplifier wich should cranck up the power to approx. 6 watt. You'll find it here.

Mute: Use the transmitter with your receiver
If you put a relay, or better a transistor switch to mute your receiver (if equiped) you can easily make a QSO HI. A simple BC338, 2N2222 at pin a" with the base biased with a 100k resistor, emmitor at the gnd and the collector fed to your receiver's mute input works fine. Or you can use a 12v relay... Every time you PTT the transistor (or when using a relay, the switch) is "shortened" between the ground, hence muting your receiver (again; if your receiver has mute capabilities). This is shown in the diagram below.

Specifications

- Peak Frequency range: 28Mc...30Mc
- Output RF PEP power: approx. 1W@14v @85% modulation
- AM modulated (CW if keyed)
- Adjustable output impedance to 50 Ohms
- Band-pass type harmonic L-filter + low-pass PII filter
- Usable voltages: Vcc 10 - 16 volts
- Average current: I= 120mA
- Xtal oscillator, 28.xxx Xtal
- Adjustable frequency of 2Kc (if C8 is replaced with a 120pF trimmer)
- Injectable with external oscillator *see text
- LF input +/- 100mV @ 1K

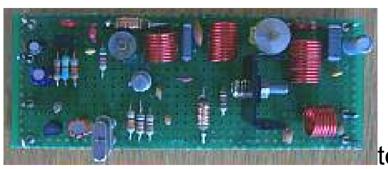
Schematic 10-meter band AM transmitter: fig1



Parts list 10-meterband AM / CW transmitter

- T1 BC557 (*modulator*)
- T2 BSX20 *oscillator* (2N2219. BC109 works also, but little less power)
- T3 BD135 *amplifier* (with heat sink isolated from the transistor)
- T4 2N2222, BC338 *mute*
- C1 = 100nF
- C2 = 47uF/16v (tantal)
- C3 = 2.2 uF/50v (changed in rev v1.5)
- C4 = 33nF (polyester) (changed in rev1.5)
- C5 = 10nF (polyester)
- C6 = 47nF (changed in rev1.5)
- C7 = 4.7uF/50v
- C8 = 10nF
- C9 = 0...22pF (60pf for 27Mc)
- C10 = 120pF
- C11 = 56pF
- C12 = 470uF/16v
- C13 = 100nF
- C14 = 47nF
- C15 = 470pF
- C16 = 6...40pF
- C17 = 12pF
- C18 = 120pF
- C19 = 56pF
- C20 = 100pF
- C21 = 470pF
- C22 = 100nF
- C23 = 10pF*(added in revision v1.2)
- C25 = 0,47uF (polyester, added in rev1.5)
- C26 = 47uF tantal (added in rev1.6)
- R1 3k9
- R2 3k9
- R3 4k7 (*rev1.6)
- R4 6k8 (*rev1.6)
- R5 1k2
- R6 220

- R7 12
- R8 100k
- R9 4k7* (added in revision 1.4)
- R10 270 (added in rev1.5)
- R11 390 (added in rev1.5)
- Ls1, Ls2 = 470 1/2 watt carbon!, 0,2 Cul turned 3 times over the entire length of the resistor (or +/- 2.7uH inductor) or use ferite bead
  note: you can also use a ferrite core of 3...4mm instead of a carbon resistor
- L1 = 0.8mm insulated copper wire, 9 turns close together, 7mm inside diameter (or 7 turns of 0.8mm wire around 8mm support (it should correspond to about 250nH))
- L2 = 0.8mm insulated copper wire, 12 turns close together, 6mm inside diameter
- L3 = 0.8mm insulated copper wire, 13 turns close together, 7mm inside diameter
- L4 = 0.8mm insulated copper wire, 7 turns close together, 7mm inside diameter
- L5 = 100uH inductor (*added in revision 1.3)
- Xtal fundamental frequency or overtone for your desired frequency (28...30Mc)
- C4, C5, C6, C25 polyester film capacitors
- (L6 and C24 removed in rev1.6)


top view

Ls1,Ls2,Ls3

Revision 1.2
C21 added to prevent the oscillator from oscillating at 2e harmonic when not connected to the amp-stage. If the oscillator is coupled/connected (via C11) with the input stage of the amplifier as designed (even if the amp stage is not powered) 2e harmonic oscillations are prevented even without C21.
To resolve this issue (in any situation) C21 has been added.
C5 was missing from the partslist
R2,R3,R4 had slight diviated values from standard available resistors (thanks Medard from Switserland!)
Revision 1.3
To improve T2 BIAS: R5 was 2k2, now 1k2. L5 added (100uH)
To improve T1 BIAS: R1 was 4k7, now 3k9
C12 changed
Revision 1.4
Ls1 (former between C6 and C7) is replaced by 100uH inductor
R9 added to improve modulation
Revision 1.5 (May 2009)
R10, R11, C25 added, and C3,C4,C6,C24 changed values: to improve linearity

Note:
Always use a dummy load for testing and adjusting the transmitter!!!

Salvatore Polito made the the 1 watt 27/28mc transmitter together with the 5 watt amplifer:

Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...). Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your antenna is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is equally important to be able to make DX QSO's.

Remember that transmitting on 10 meter band (or building and using the transmitter) needs a valid radioamateur license!

12 meterband AM / CW transmitter project

ON6MU
Home

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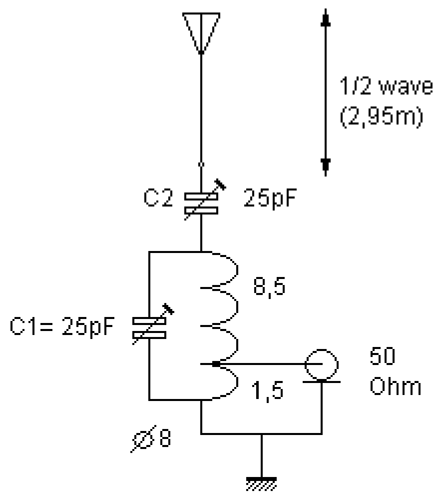
VHF 1/2wave vertical antenna for the 6-meterband (50 Mhz)
RE-A50V12

By Guy, de ON6MU

Schematic fig1



[1/2 wave antenna principle]

A much better type of antenna then a simple quatre wave and that has more gain is the 1/2 wavelength vertical. We know that the impedance of the 1/2 dipole is 70 Ohms when we attach the coax in the middle, but what if we were to attach our coax directly to the end? The impedance at this point is high, very high, so we must make a matching device to match the antennas impedance to the 50 Ohm coax. What would happen if we did not use this matching device? Well...you would know that this would result in a very very high SWR.
The bandwidth of these antennas are good, they can easily span the entire 50Mc band and more with a low SWR. But, in this design, the bandwidth is limited to approx. 600kc (without re-tuning C1 or C2). This allows you to tweak the antenna to your desired band and avoid interference and reduce intermodulation.
The antenna and ground are connected across the tuned circuit while a 50-ohm coaxial cable is connected to taps on the inductor. The tuned circuit presents a high impedance to the antenna and the tapped inductor steps this impedance down to 50 ohms. Adjusting the tuning capacitor tunes out slight reactance variation if the antenna is not an exact electrical half-wavelength.

[Parts list]

- 4 pieces of 1 meter alu or copper tubing:
  - one 18 mm diameter
  - one 15 mm diameter
  - one 12 mm diameter
  - one 10 or 8 mm diameter
- 1 female PL 259 chassis
- some cul wire (isolated wire like from a transformer etc.) of 0,8 mm thick
- a coil holder of 8 mm diameter
- two 25pF regulable capacitors
- A robust PVC box of approx 30x50x18 mm and 2mm or more thick
- a piece of hard insulating material that snuggly fits inside the base tube, like:
  fyberglass, nylon, hard pvc, hard wood, bamboo etc... as long as it's very strong, stress and weather resistant.
- and a few innox hose clamps

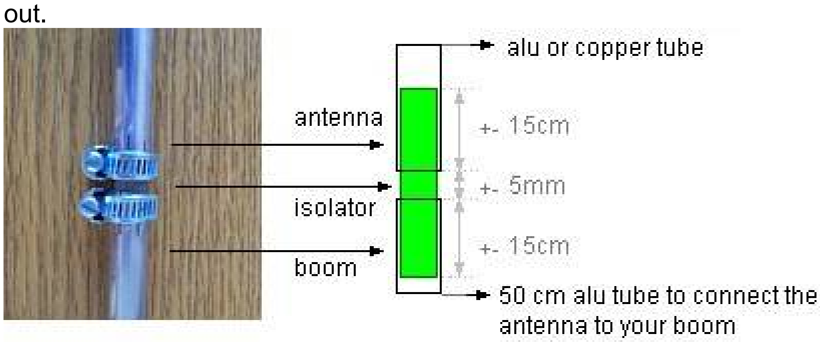
Note: there are many ways to build your antenna and I'm sure some can come up with better mechanical designs then described here although the design and material used here is cheap and easy to find. Also, the diameters of the tubing described here is not too critical.

Links of interest:

The antenna

- Construction:
  The vertical itself is constructed out of four overlapping sections of aluminum tube whose sizes are given.

  - saw the 1 meter 18 mm alu tube in half. One part (50 cm) will be used as a boom and the other as the first part (also 50cm) of the antenna.
  - saw some grooves (approx 1,5 cm) in both halves of the tube to allow a hose clamp to tighten everything up.
  - same goes for the other tubes that fits inside eachother. All tubes are firmly fixed together by using hose clamps.
  - Measure from the base up 2,95 meters. You can alwyas tune the antenna to its best SWR by sliding the top tube in or out.



  - saw a piece of that hard insulating material of your choice and fit it 10 cm in the antenna and boom part and leave a gap of 3 mm between them.
  - hammer down one end of each of the 3 radials (3 x 22 cm) so it becomes a bit flatten. This will make things easier to screw tight with the hose clamp. These radials are fitted on the boom section.

- The little black box:

Here is where all the secrets are stored HI. I used a little plastic box where I placed the LC-circuit and the PL connector.
I also drilled two little holes where you can regulate the two capacitors with an little isolated screwdriver. Afterwards you can seal the holes up to prevent moisture from entering the box.

- The LC tank-circuit:
- Wind 10 turns of 0,8mm cul wire around the 8mm coil holder and make a tap at 1,5 turns. There is no spacing between the windings.
- The smallest part (the "cold side" 1,5 turns) of the coil is where your centre part of the connecor/coax is connected to. The above schematic shows how.

- As you can see there are two wires comming out of the box (which contains the LC): one for the antenna and the other for the ground (being the connecting boom piece).


- Connect the wires accordingly and be sure to seal everything up.

- Tuning:
- Get your old (t)rusty SWR-meter and and some 50 Ohms coax and connect your transceiver to it.
- Set the two capacitors to halfway to start with.
- Mount your antenna temporary 1,5 meters from the ground for the first tests and measure the antenna length (the boom piece NOT included) at 2,95 meters and try to ground the boom.
- Find a CLEAR frequency and set your transceiver to MINIMUM possible power and use a carrier type modulation (CW, AM, FM).
- Tune C1, which is the most important and critical capacitor, till the SWR gets a s low as possible on your desired centre frequency (51 Mc)
- Then tune C2 till the SWR is even more lowered or even 1:1.
- Repeat the last two steps at location if needed
- Fine tuning your antenna can be done by sliding the tubes in or out. Sometimes when your place your antenna higher or when the antenna has obstacles in its proximity the SWR can vary from the one you noted first. Raising or lowering the length of the antenna should fix it.

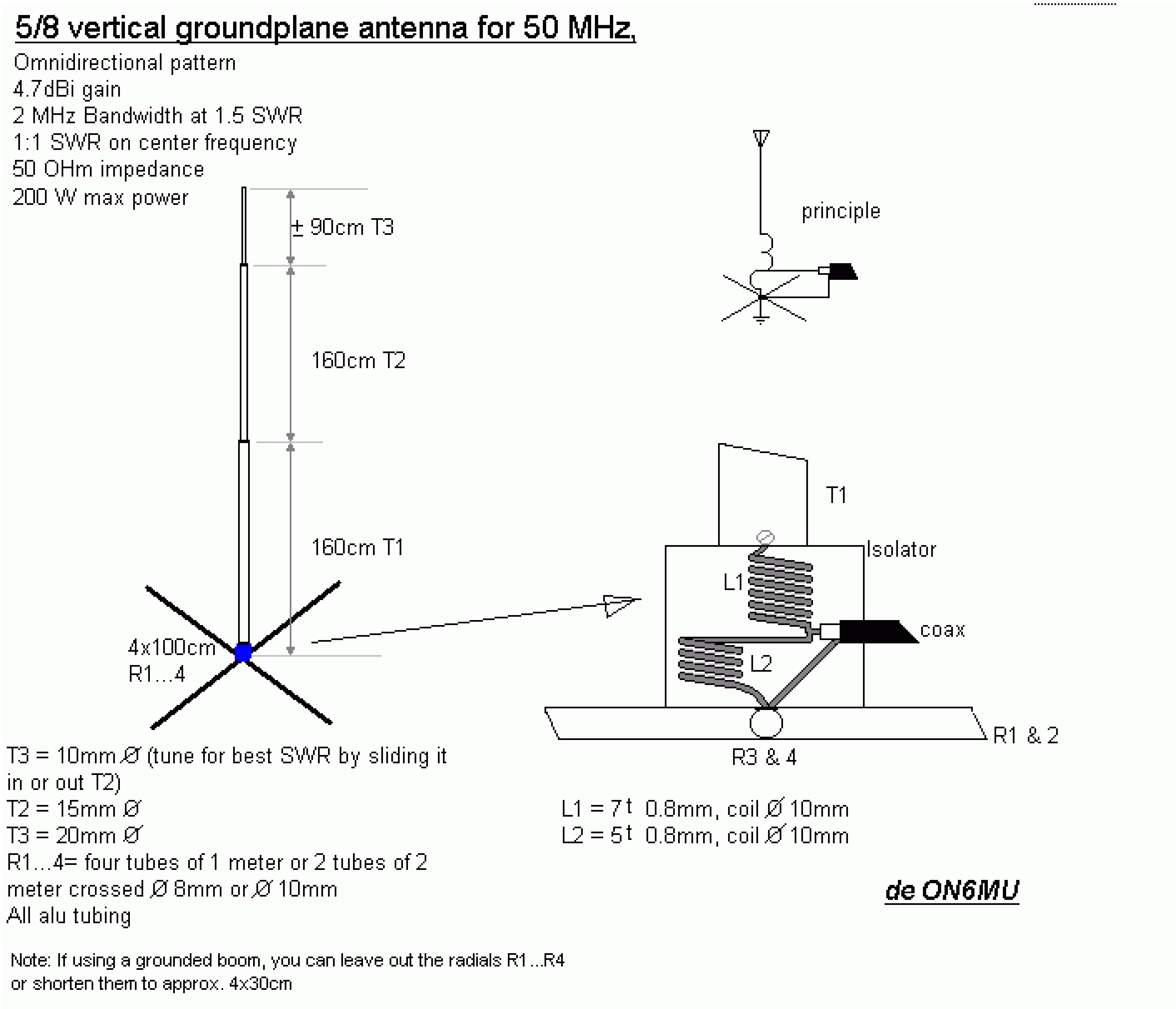
Highlighted

Specifications ON6MU Vertical Antenna RE-A50V12

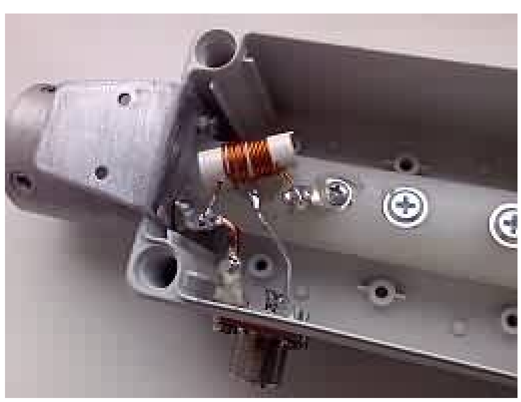
- Total length (including the 50cm mounting boom piece): 3,5m (2,95m effective)
- centre frequency: 51 Mhz
- bandwidth: 2 Mhz
- maximum tunable frequency range: 49...53 MHz+-
- impedance: 50 Ohms
- Gain: 3,6 dBi
- Maximum power using the components described: 20 watt
- NO counterpoise or radials needed if the boom is grounded or the boom length is >= 1,5m
- DC grounded (no static buildup)
- Height: 2,95m
- If needed, it can be disassembled into a very small bundle no longer than the longest element.

Be sure to seal everything up to avoid moisture, corrosion etc...

5/8 vertical groundplane antenna for 50MHz RE-A50V58



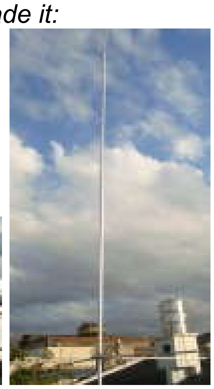
This is how Greg, **SP5LGN** constructed my 5/8 lambda 6-meter GP antenna:

Click to enlarge
Many thanks Greg!

How Horacio LU9DFN made it:

Click to enlarge
Many thanks Horacio!

SWR:
You can fine-tune the SWR to peak in the bandsection you are planning to use the 5/8 groundplane antenna by:

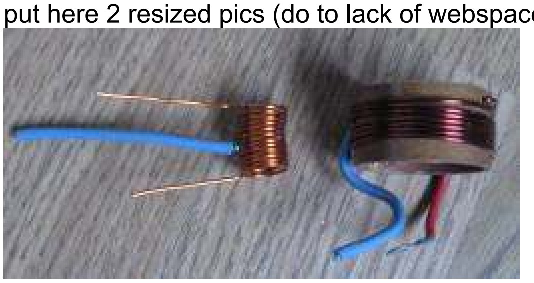
- - shorten or lengten the radiating element (vertical section)
- - shorten the radials
- - experiment with the coil spacing

Today's specials:

.**ON6MU Homebrew projects**
.Radioamateur related projects

.**ON6MU Ham mods**
.Modifications of transceivers

PA3BEN sent me a lot of pics on how to convert an old CB antenna using my schematic (shown here above) for 50Mc! I've put here 2 resized pics (do to lack of webspace, sorry):



Thanks Ben!

Please take a look at my 50mc wide-spaced yagi antenna

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ON6MU

QRP Magnetic longwire balun with VHF-splitter

RE-ABU3HF/S

By Guy, de ON6MU

About the MLB (magnetic longwire balun RE-ABU3HF/S)

This Magnetic Longwire Balun (MLB) makes it possible to efficiently use a coaxial lead-in cable with all forms of longwires, T-forms or other types of wire antennas, without the need for an antenna tuner. A very low loss magnetic transfer of energy from the antenna to the receiver is accomplished and static noise is reduced. Your coax is much less susceptible to interference. You can even connect a dipole to it.
It works fine with a heavy duty 41 foot (12.5 meters) wire, some nylon rope and a quality insulator. At the feed-line end the antenna is terminated with the Magnetic Longwire Balun. This balun permits an exceptionally low loss transference of antenna energy to your coax feed line. The result is significantly reduced static noise on long, medium wave and the shortwave bands.

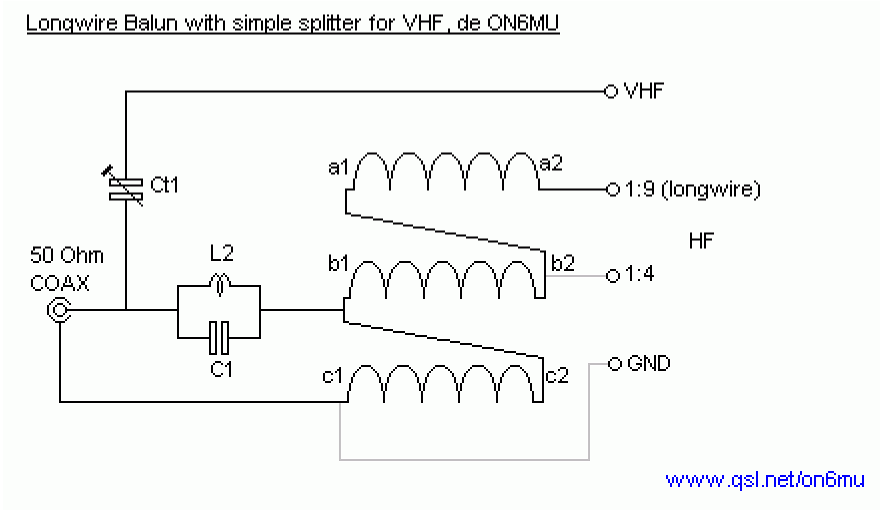
You do not have to Earth/Ground the Green wire sticking out of the top, but it helps minimize interference if you do. Grounding the balun / coax (pin c1) to a good earth made between 3 and 6 dB improvement on noise and QRM, even though the station was well-grounded.

You could add a shoke inside (or outside) the balun housing to prevent even more from coax radiating too. A few feritte beads over the coax or turn a piece of 50 coax a few time around a feritte core. If possible inclose the shoke inside the balun housing or as close as possible to the SO239 connector.
Long-wire antennas are directional, so bend yours to allow both N-S and E-W orientation. Height is dependent on your location and surrounds … experiment!!

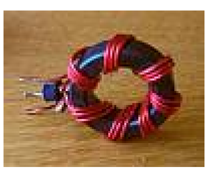
you can add an extra output as described in the schematic if needed (1:4)

L2,C1 blocks VHF signals from entering the balun. Ct1 tunes the VHF antenna and limits the lower frequencies from entering the VHF rod. You can calibrate Ct1 by soldering 1 watt 50 Ohm carbon resistor (or dummy load) between Ct1 (VHF pin) and the ground of the connector. Use a low power setting (0.5 watt) and tune Ct1 to 1:1 SWR.

Schematic QRP Longwire balun with VHF-splitter



Parts list

-  toroid, feritte core of 15mm, or small Amidon red ring core, FT50-43 or T50-7 or for higher power: or Philips 4C6 or 4C65 (pink color), Amidon T130-2 red or T200-2 red
- 3 pieces of insulated wire (Cul) of 0,8mm
- CT1=5...30pF capacitor trimmer (green)
- C1 = 10pF
- L2=0,8mm Cul, 4,5 turns, 5mm diameter
- 2 x 25mm 3mm diameter weater resistant bolts (innox etc...)
- "banana" type plug for VHF antenna (no ground needed)
- SO239 connector
- electrical junktion box (painted after)

Specifications

- Peak Frequency range: 100kc...30Mc (mostly depending on the core) and 144...146Mc
- Max. RF power CW: 5...10W (also depending on the mismatch of the antenna and the transmission intervals)
- Max. RF power SSB: 10...15W (also depending on the mismatch of the antenna and the transmission intervals)
- Output impedance to 50 Ohms coax
- 1:9 output for longwire
- 1:4 experimental
- Rod VHF 1/4 (or 3/4) wave electrical length for 144...146Mc

Another related project: Magnetic Longwire Balun (MLB) also usable for dipoles

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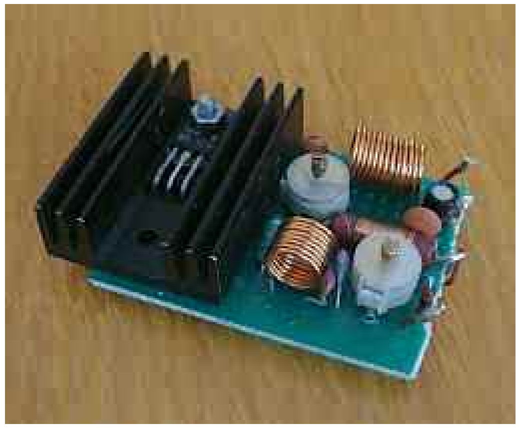
ON6MU
Home

Homemade QRP transmitter with Xtal oscillator for QRP. AM modulation and CW for the 10-meter band and 12-meterband. For radioamateurs using an antenna, schematic, HF, home made QRP transceiver, homebrew for 12meterband 28Mc, 25Mc, 30Mhz, 27Mhz, 28Mhz, 29Mhz

ON6MU

AM/FM/CW RF Power Amplifier for the HF 10 or 11 meterband (28Mc/27Mc) RE-PA5HF10 and RE-PA7HF10



prototype

By Guy, de ON6MU

About the 10-meterband HF amplifiers RE-PA5HF10

This project and your efforts will provide you with a 0.5 watt input to 5 watt output. The linear amplifiers are ment for use with QRP CW/FM/AM transmitters on the 10meter amateur band (but can also be tuned for 27Mc) can be powered from a 12 volt DC supply. The design is a good balance between output power, physical size. The completed amplifier will reward the builder with a clean, more powerful output signal for a QRP rig when radio conditions become marginal. The first project uses a "classic" RF transistor. The second project uses a MOSFET and can deliver 7 watts.

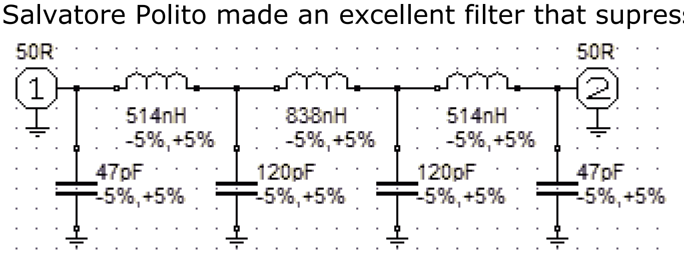
Bias

Power amplifiers used in base stations require biasing for proper RF performance on SSB. The first design doesn't use it as it is designed for carrier modulation modes (like AM,FM,CW). It can be used for SSB, but the modulation won't be clean and smooth. It will sound a bit like those Zetagi amps. The second design (RE-PA7HF10) does use proper BIAS applied to Q1 to have clean proper and correct SSB modulation using this amplifier.

Filter

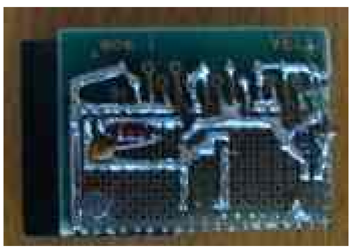
RF purity and harmonic suppression is done here. Also allowing the transistor to be coupled to the antenna system through antenna impedance matching circuitry (C5,6,7 and L2). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands.
This 3-element L-type bandpass filter circuit cleans out any remaining harmonic signals.
To allow maximum filtering of the 2nd harmonic (56Mc) we could add a parallel LC blocking filter tuned to 56Mc. For 27Mc we need a 54Mc blocking filter.
For 28Mc add in series with the output a coil L=5turns, 0.9mm, 7mm inside diameter and parallel on this coil a 47pF capacitor (or use a trimmer of 60pF to allow peaking the filter to the band you want to use).
Another PI-filter would be recommended too. The reason for this project is to show the working principle of a non-biased transistor based RF amp, so I kept it simple to the bare necessities.

Salvatore Polito made an excellent filter that supresses the 2nd harmonic (base freq x 2) -40dB:



The inductors are air inductors made with 0.8mm enameled wire over a 7mm support:
- 514nH => 12.5 turns
- 838nH => 18 turns

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.
I made this amplifier on a board of only 6cm x 4cm including the heatsink!



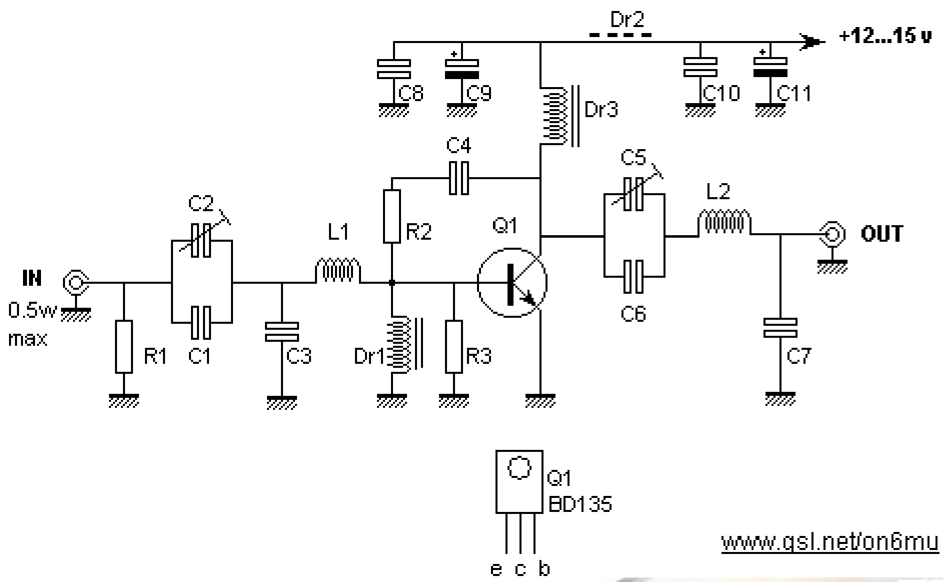
RE-PA5HF10: 10-meterband Amplifier settings

Connect a 50 Ohm dummyload and a powermeter on the output.
Connect a SWR-meter between the input of the amp and your transmitter (be sure the transmitter is set to low power +/-500mW and set to your desired centre frequency).
Set C2 and C5 to the middle. After carefully mounting all parts and using as short as possible connections between the parts, gently add voltage to the amplifier while checking the current. The only current you should see is a the liddle idle current of Q1. Increase the voltage to 12 volts. Check current again. It should (at this stage) be lower then +/- 2mA.

Still all working as planned? Excellent! Now carefully turn C2 till you get maximum the best SWR and output power (whilest checking the input SWR on your transceiver or SWR meter). And finally tune C5 and C7 to maximum power. If needed re-tune C2 and C5 till you reached the maximum and best SWR on the centre frequency. Current should be around 0.5 Amp +/- @ 14v (depending on the voltage and input power).

Do not forget to mount Q1 on a heat sink isolated electrically from the transistor.

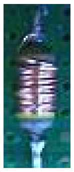
RE-PA5HF10, 28Mc 5watt amplifier, de ON6MU



Parts list 10-meterband power amplifier

- Q1 BD135 (with proper heatsink isolated from the transistor)
- C1 10p
- C2 40pF trimmer
- C3 56p
- C4 560p
- C5 50pF trimmer
- C6 33pF
- C7 50pF trimmer
- C8 10nF
- C9 10uF
- C10 100nF
- C12 47uF
- R1 1k 1/2 watt carbon (optional: if the driver needs a non-conductive load. Can usually be left out)
- R2 220
- R3 1k 1/2watt carbon (you can use a ferrite core of 3...4mm if no carbon resistor is available)
- L1 = 0.9mm CuI (insulated copper wire), 7.5 turns close together, 7mm inside diameter

- L2 = 0.9mm Cul (insulated copper wire), 13 turns close together, 7mm inside diameter
- Dr1 = 10uH inductor or 0,4mm Cul (insulated copper wire), 60 turns close together over a 1k 1/2 watt carbon resistor (you can use a ferrite core of 3...4mm if no carbon resistor is available)
- Dr2 = ferrite bead with a few turns of wire
- Dr3 = 1.5uH...2uH inductor or 0,4mm Cul (insulated copper wire), 30 turns close together over a 1watt 10k carbon resistor (you can use a ferrite core of 3...4mm if no carbon resistor is available)
  ....or use a toroid T80-6 (yellow) with 18.5 turns of 0.5mm silver plated wired (Thanks to Salvatore Polito).

Dr1 

Note:
Always use a dummy load for testing and adjusting the amplifier!!!

[Specifications RE-PA5HF10]

- Tuneable frequency range: 26Mc...30Mc
- Output RF power: at least 3.5W @ 13.8v - 5W@16v
- AM/CW/FM (SSB with modulation Q limitations)
- Adjustable output impedance to 50 Ohms
- Adjustable input impedance to 50 Ohms
- Efficient band-pass type harmonic L-filter filter at the output
- Efficient band-pass type harmonic L-filter filter at the input
- Usable voltages: Vcc 10 - 16 volts
- Average current I: +/- 0.5A @ 13.8 v
- VSWR overload resistant (not infinite)
- Can be used without complex BIAS if only needed for CW/AM/FM/FSK type modulation
- Compact and easy design (only 6cm x 4cm with heatsink)

Salvatore Polito made the amplifer together with the 1 watt 27/28mc transmitter:

Allmode RF Power Amplifier for the 10 meterband (28...30Mc)
RE-PA10HF10

By Guy, de ON6MU

About the 10-meter band HF amplifier RE-PA7HF10

All is already explained above (17-meter band amplifier): Read it here

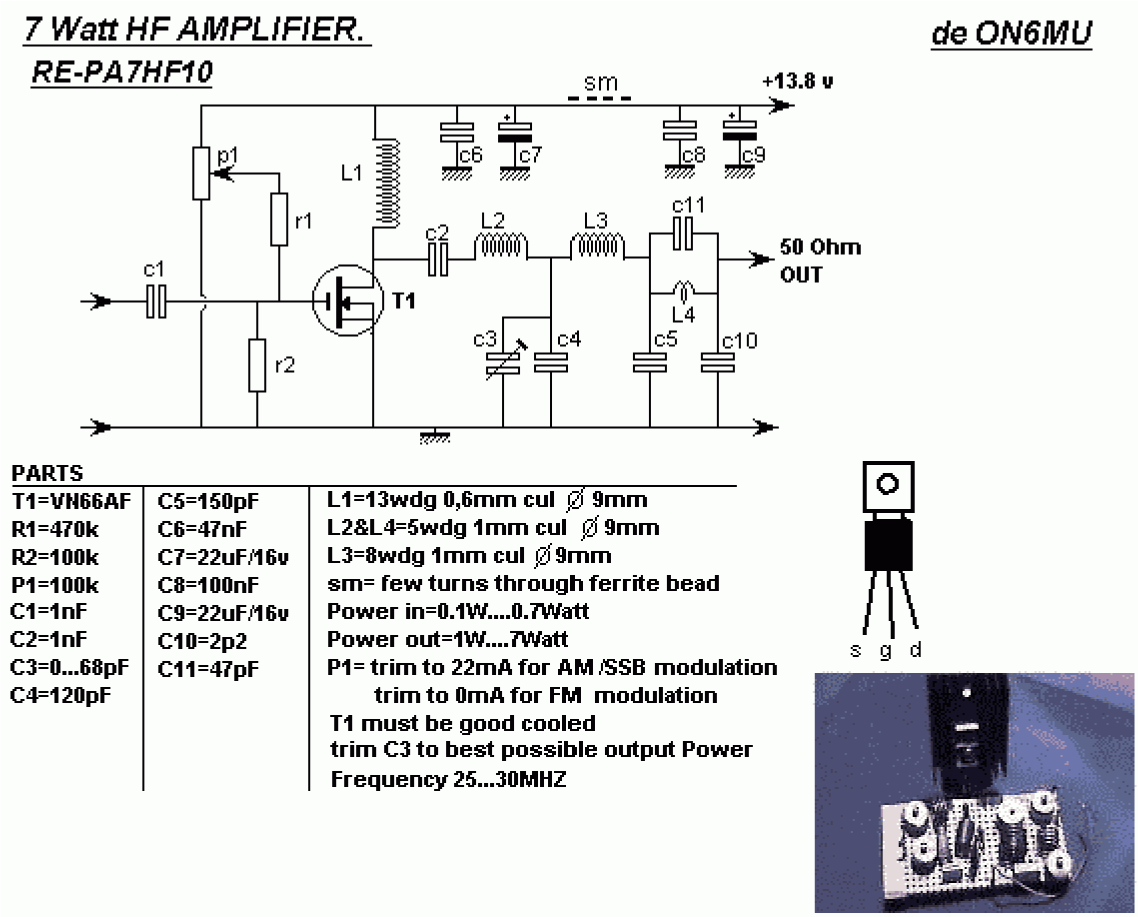
10-meterband Amplifier settings

Connect a 50 Ohm dummyload and a powermeter on the output.
Connect a SWR-meter between the input of the amp and your transmitter (be sure the transmitter is set to low power +/-500mW and set to your desired centre frequency).
Set P1 to the minimum (ground potential).
Set C3 to the middle. After carefully mounting all parts and using as short as possible connections between the parts, gently add voltage to the amplifier while checking the current. The only current you should see is a the liddle idle current of Q1. Increase the voltage to 12 volts. Check current again. It should (at this stage) be lower then +/- 2mA.

Now gently turn P1 till you get approx. 25 mA. Depending on the type of MOSFET the BIAS current can vary somewhat.

Do not forget to mount T1 on a heat sink isolated but electrically from the MOSFET.

If you plan to use only FM/AM modulation then set P1 to 2mA or less, although the design allows you to set the BIAS to +/-25mA and use it in all modulation modes.



Note:
Always use a dummy load for testing and adjusting the amplifier!!!

Specifications

- Peak Frequency range: 27Mc...29Mc
- Output RF power: at least 7W @ 13.8v
- Input power 0.7watt max
- All modulation modes
- High efficient band-pass 9-element harmonic block- lowpass PII filter
- Usable voltages: Vcc 10 - 18 volts
- VSWR overload resistant (not infinite)

Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing

harmonics/interference...). Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your antenna is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is equally important to be able to make DX QSO's.

Remember that transmitting and/or using an power levels higher then your local license permit is illegal without a valid radioamateur license!

Another related project:1watt 10 meterband transmitter project

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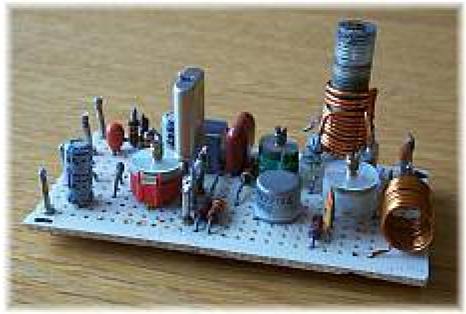
QRP AM(cw) Transmitter for the 10 meterband RE-TX02HF10



By Guy, de ON6MU

About the QRP AM/cw 10-meter band transmitter

In this project, you will make a simple low-power broadcast-type circuit, using a crystal oscillator integrated circuit and an a collector modulated AM oscillator. You can connect the circuit to the an amplified microphone (no amplified microphone has a to low output voltage to work. at least 100...200mv is needed). You could also add a LF preamp stage of one transistor to allow connecting a microphone directly.

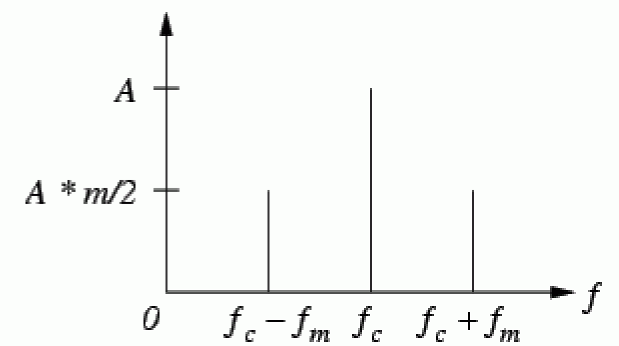
You'll see that you can receive the signal through the air with almost any AM radio receiver. Although the circuits used in radio stations for AM receiving are far more complicated, this nevertheless gives a basic idea of the concept behind a principle transmitter. Plus it is a lot of fun when you actually have it working! Remember that transmitting on 10 or 12 meter band you'll need a valid radioamateur license!

A wide range of different circuits have been used for AM, but one of the simplest circuits uses collector modulation applied via (for example) a transformer, while it is perfectly possible to create good designs using solid-state electronics as I applied here (T1 2N2905).

The transmitter is build as a Colpitts Oscillator with a strong 2N2219(A) transistor. HF-output of the oscillator is 100 to 350 mW, depending on the supply voltage of 9 to 18 Volts. The transmit frequency is stabilized with the 28Mhz crystal. A slight detuning of approx 1kc is possible by using Ct1 trimmer capacitor. The oscillator signal is taken from the collector of T2 by induction and via a low-feedthrough filter and guided to the output via an L-filter circuit cleaning up the signal pretty good. The oscillator is keyed by T1 and the morse key (S). By keying the morse-key T1 is not been used for modulation and is biased, hence lets T2 freely oscillate.

The oscillator uses a single coil and crystal. The coil is tuned to the output frequency, which may correspond to the crystal frequency, or a harmonic.

AM



The resulting AM spectrum using sinusoidal carrier and modulating waveforms.

Amplitude Modulation (AM) is a process in which the amplitude of a radio frequency current is made to vary and modify by impressing an audio frequency current on it.
This was the first type of modulation used for communicating signals from one point to another and is still the simplest to understand.
A radio frequency current has a constant amplitude in absence of modulation and this constant amplitude RF carries no information, i.e. no audio intelligence and is of no use to radio telephone (voice communication), but has application in morse code communication.
In its basic form, amplitude modulation produces a signal with power concentrated at the carrier frequency and in two adjacent sidebands. Each sideband is equal in bandwidth to that of the modulating signal and is a mirror image of the other. Thus, most of the power output by an AM transmitter is effectively wasted: half the power is concentrated at the carrier frequency, which carries no useful information (beyond the fact that a signal is present); the remaining power is split between two identical sidebands, only one of which is needed.

CW

CW is the simplest form of modulation. The output of the transmitter is switched on and off, typically to form the characters of the Morse code.
CW transmitters are simple and inexpensive, and the transmitted CW signal doesn't occupy much frequency space (usually less than 500 Hz). However, the CW signals will be difficult to hear on a normal receiver; you'll just hear the faint quieting of the background noise as the CW signals are transmitted. To overcome this problem, shortwave and ham radio receivers include a beat frequency oscillator (BFO) circuit. The BFO circuit produces an internally-generated second carrier that "beats" against the received CW signal, producing a tone that turns on and off in step with the received CW signal. This is how Morse code signals are received on shortwave.

Although this design is primarely designed for AM, it can be used for CW with a slight whistle like sound, but is still usable as CW transmitter by keying S.

RF Oscillator

Is been carried out by T2 (NPN 2N2219). This is the stage where the carrier frequency intended to be used is generated by means of Crystal Oscillator Circuitry or capacitance-inductance based Variable Frequency Oscillator (VFO). The RF oscillator is designed to have frequency stability (Xtal) and power delivered from it is of little importance, although it delivers 250mW@13v , hence can be operated with low voltage power supply with little dissipation of heat.

You could add a switch (very short connections if using an ordinary switch) to select different Xtal's (frequencies). You could also use a more effective diode-based switch I've build here. This hasn't got the problems with longer connections at all.

Filter

RF power amplification is also done here and this stage is coupled to the antenna system through antenna impedance matching circuitry (L1/L2). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands (Ct3, L3, C10). This 3-element L-type narrow bandpass filter circuit for the desired frequency cleans out any remaining harmonic signals very efficiently.

Modulator
Is all done by T1 (PNP 2N2905). Audio information is impressed upon the carrier frequency at this stage. Do to selective components circuits (C3, C4, C7, C5) the voice component frequencies are enhanced, whilest others are suppressed (bandwidth +- 3kc/side) keeping it between HAM-radio specs.

Why over modulation is not desirable?..
Over modulation is not desirable, i.e. modulation should not exceed 100 %, because if modulation exceeds 100 % there is an interval during the audio cycle when the RF carrier is removed completely from the air thus producing distortion in the transmission.

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.

More power
You can connect the output to my power FET based 10-meterband power amplifier wich should cranck up the power to approx. 3 watt. You'll find it here.

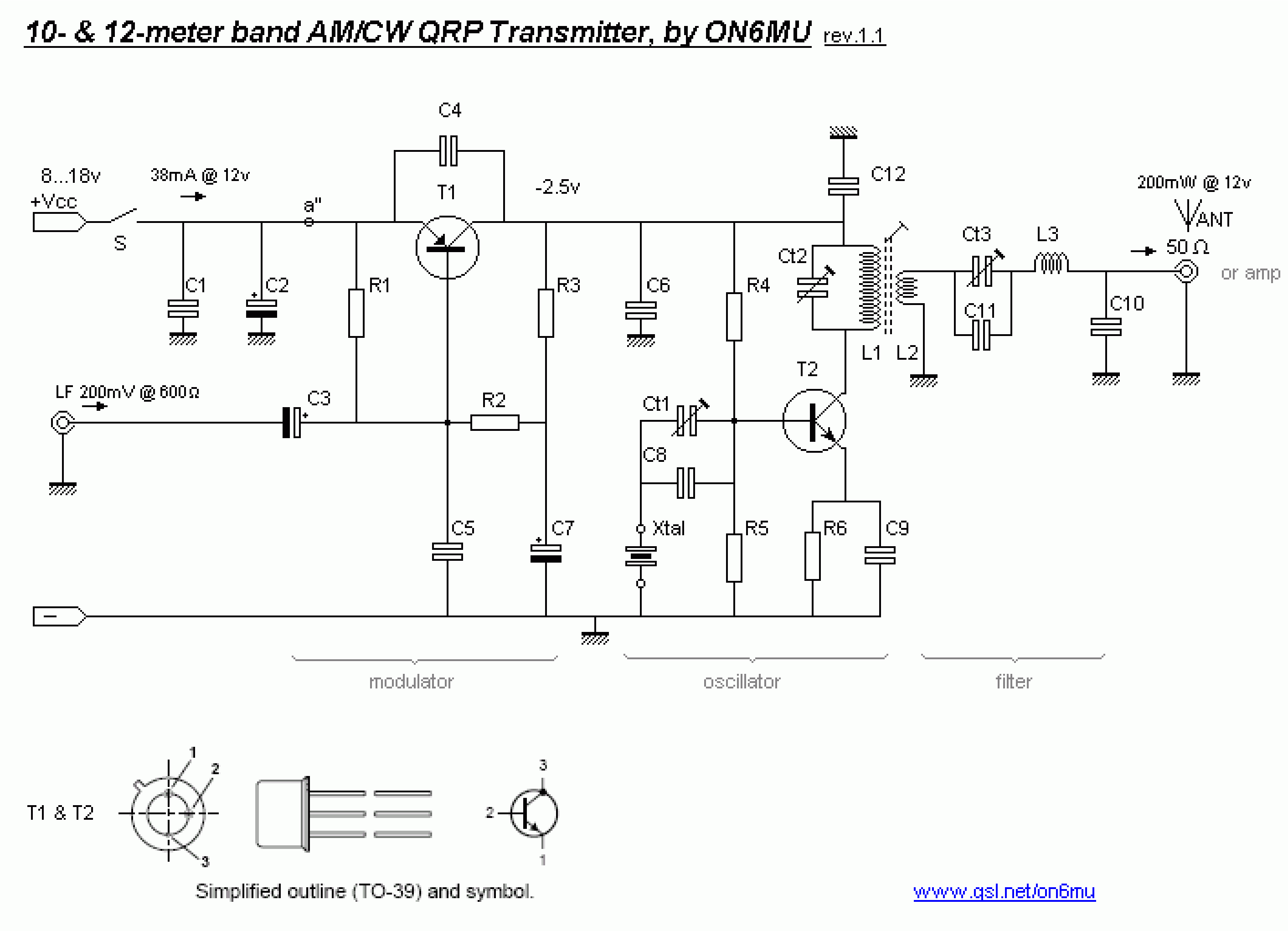
Use it with your receiver
If you put a relay, or better a transistor switch to mute your receiver (if equiped) you can easily make a QSO HI. A simple BC338, Bc547, 2N2222 at pin a" with the base biased with a 100k resistor, emmitor at the gnd and the collector fed to your receiver's mute input works fine. Or you can use a 12v relay... Every time you PTT the transistor (or when using a relay, the switch) is "shortened" between the ground, hence muting your receiver (again; if your receiver has mute capabilities).

Revision 1.1
C12 needs to be connected as close as possible between the gnd and the L1 cold side (top).

Specifications

- Peak Frequency range: 27Mc...30Mc
- Output RF power: 100mW@9v - 200mW@12v - 250mW@13.8v - 300mW@16v // all @ 85% modulation
- AM modulated (CW if keyed)
- Adjustable output impedance to 50 Ohms
- Band-pass type harmonic L-filter
- Usable voltages: Vcc 5 - 16 volts
- Average current: I= 27mA@9v - 38mA@12v - 45mA@16v
- Xtal oscillator, 27...30.xxx Xtal
- Adjustable frequency of 1Kc
- LF input +/- 200mV @ 600 Ohm

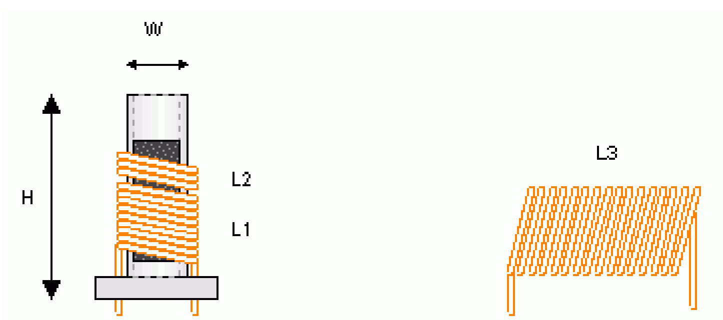
Schematic 10-meter band transmitter: fig1



Parts list 10-meterband transmitter

- T1 2N2905A or 2N2905
- T2 2N2219A or 2N2219
- C1,C4 = 100nF
- C2 220uF/25v
- C3 2.2uF/25v
- C5 10nF (polyester)
- C6 47nF
- C7 2.2uF/25v
- C8 12pF
- C9 150pF
- C10 150pF
- C11 10pF

- C12 470pF
- Ct1= 5...80pF (red) frequency +- 1kc
- Ct2= 5...22pF (green) tuning (set at half position, tune at max output)
- Ct3= 5...40pF (white) set at half position and tune at max power
- R1 3k3
- R2 1k8
- R3 1K8
- R4 4k7
- R5 1k8
- R6 82
- L1 = 0.8mm insulated copper wire, 9 turns close together, 9mm outside diameter (7mm inside, 9mm heigh)
- L2 = 0.8mm insulated copper wire, 3 turns close together, on same coil holder as L1 with turnable feritte core
- L3 = 0.6mm insulated copper wire, 16 turns, 9mm outside diameter (+-8mm inside, 11mm long)
- Xtal for your desired frequency +- 1kc (no overtone!)



W=7mm, H=25mm, L1=9turns, L2=3turns, L3=16turns 9mm diameter
L3 should be coated with Q-Dope to minimize possible microphonics (noise from physical circuit board vibrations).
Note: *The core is needed to tune to the lowest frequency possible with this design, which is +/- 26.5mc. Could be you wont needed for 28mc >*

Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...). Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your antenna is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the

street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is equally important to be able to make DX QSO's.

Remember that transmitting on 10 meter band needs a valid radioamateur license!

12 meterband transmitter project

ON6MU

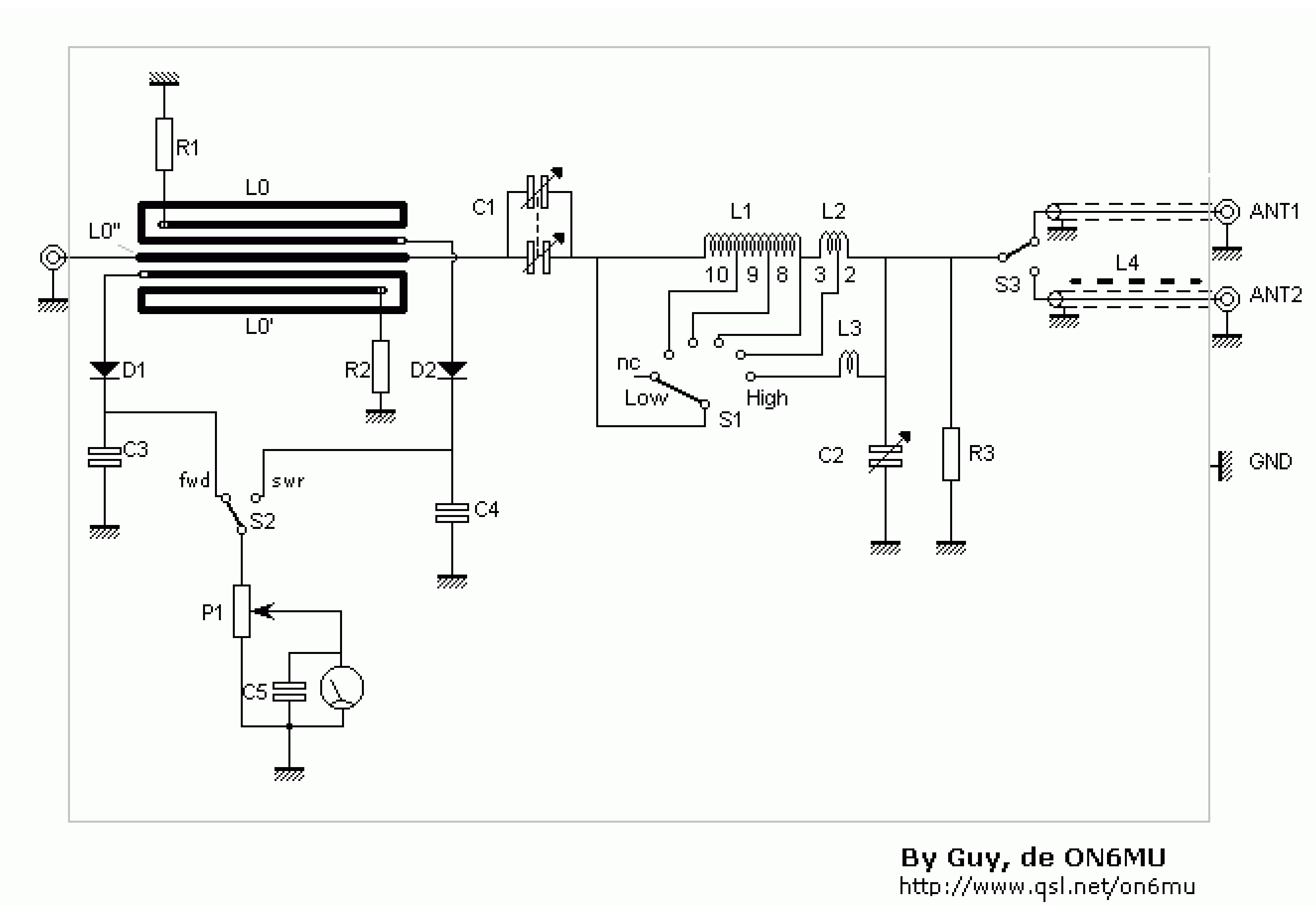
Home

ON6MU

HF/6M Antenna Tuner Preselector and Antenna Switcher RE-AT1HF6

By Guy, de ON6MU
revision 3

RE-AT1HF6 Schematic fig1



Parts list

- alu box of 200mm X 130mm X 70mm
- 3 female PL 259 chassis

- Analog Meter (as sensitive as possible and calibrate the scale with a good SWR meter)
- C1 = variable capacitor of +/- 2 x 500 pF (air spaced)(1kv). C1 isisolated from the ground!
- C2 = variable capacitor +/- 280pF (air spaced)
- S1 = 6 pos. switch
- S2 = mini toggle switch
- S3 = solid 380v/10A toggle switch
- P1 = 10k log variable resistor
- D1, D2 = 2 germanium diodes AA15,AA109 etc.
- R1, R2 = 50 Ohm (2 x 1/4watt 100 Ohm parallel)
- R3 = 4k7 1watt carbon (or non-inductive resistor)
- C3,C4 = 4n7
- C5 = 22nF
- L1 = 1,5mm insulated copper wire, 27 turns close together, 19mm outside diameter (16mm inside)
  taps at 10, 9 and 8
- L2 = 1,5mm insulated copper wire, 5 turns with 1mm space, 19mm outside diameter (16mm inside)
  tap at turn 3
- L3 = 1 mm insulated copper wire, 4 turns no space, 9mm outside diameter (7mm inside)
- L4 = RG-58 coax wound around a 8 cm long carbon rode and fixed with tape
- L0 & L0' = 1,5 turns approx. 6 cm as long as the centre part L0" which is 1 mm separated.
  you also can use self-adhesive copper tape instead of wire or a toriod.
- L0" = 6 cm long copper wire (or copper line of 5 mm wide if you use a PCB)
  (L0, L0' and L0" makes out the SWR meter which is laid out as in the schematic fig1)

Specifications

- long wave, medium wave and shortwave preselector tuner lets you boost your favorite stations while rejecting images, intermod and other phantom signals on your shortwave receiver.
- frequency range: 2Mc...52Mc
  180m band depending on the mismatch of the antenna used and/or maximum inductance.
  Experimenting with the coils can be desirable.
- 150 Watt +-
- switchable between two antenna's
- shoke antenna output

- band-pass type (harmonic filter)
- pre-selector
- SWR meter (if needed, else you can simply leave it out HI)

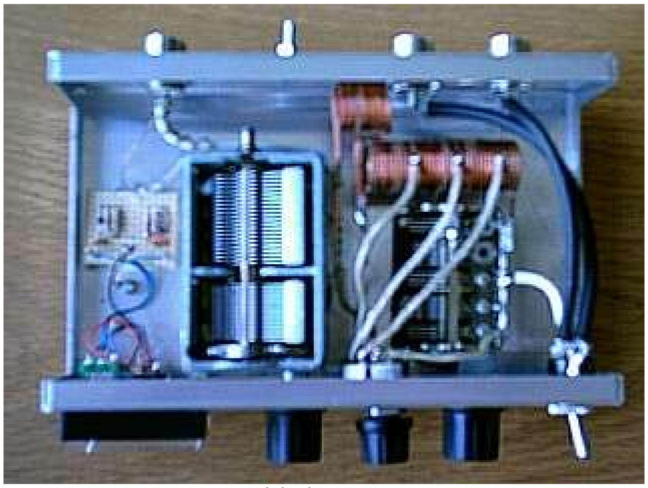
Revision 2 notes:

- improved SWR bridge
- R3: to drain any possible static build-up on your antenna

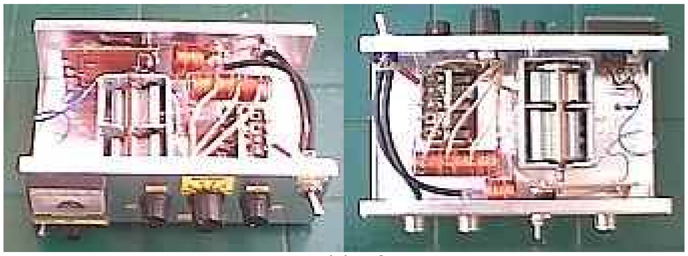
Revision 3 notes:

- L3 added and last of L1 tap changed to allow tuning up to 52MHz!
- L1 changed (was at 9, 9, 9 and 4) for better bandspread and higher top frequency range
  L2 (was 1mm, 10 turns close together, 18mm outside diameter) removed in revision 3 (click on the link for revision 2).
- Choke antenna output added to prevent HF-currents on the transmission cables (to improve immunity when using badly tuned antenna's)
  Can be used on good antenna's too of course.
- Notes: remember that you can always experiment with inductance (L1, L2, L3) to best suit your specific needs.

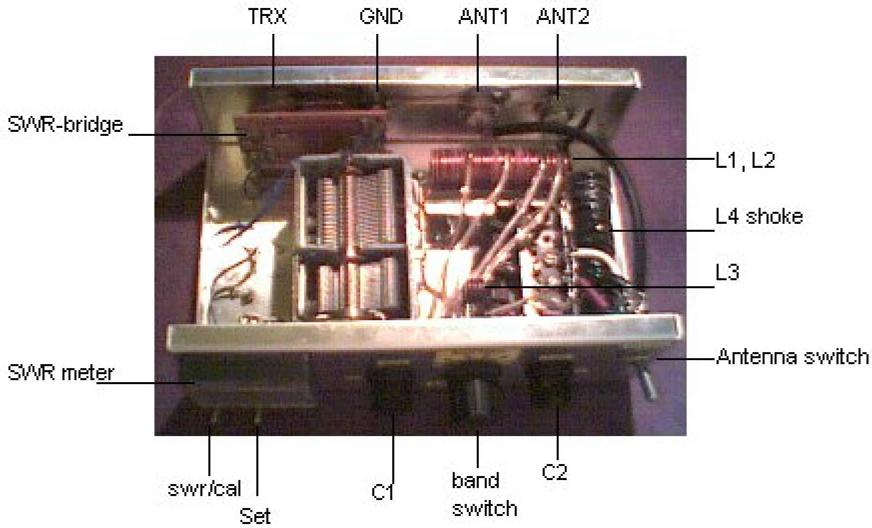
Pictures



original prototype

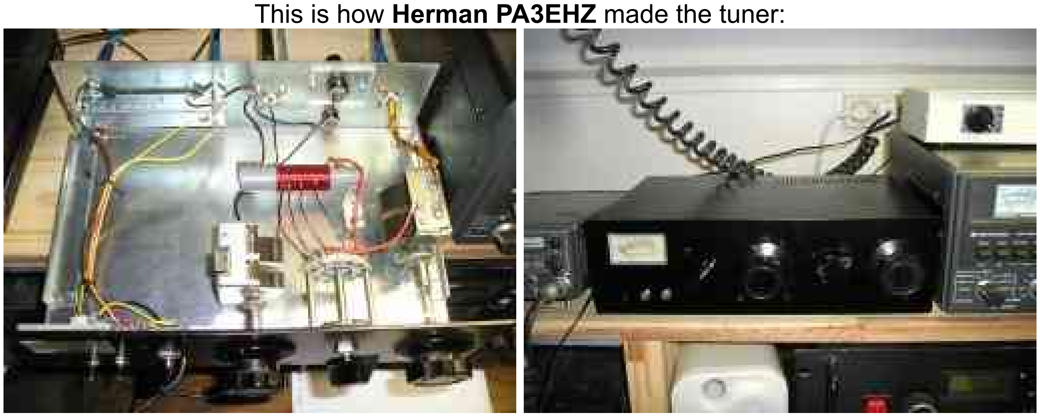


revision 2



All revisions

This is how **Herman PA3EHZ** made the tuner:



click images to enlarge
Thanks Herman for the pics!

If you elect to use an antenna tuner, it is extremely important that you understand exactly how to use tuners and what they can and cannot do. A few watts of RF can easily become lost in an incorrectly adjusted antenna matching device. I cannot overemphasize the priority of a clean, efficient connection of the amplifier output to a resonant antenna.

Don't forget to check these out:

.**ON6MU Homebrew projects**
.Radioamateur related projects

.**ON6MU Ham mods**
.Modifications of transceivers

73"

ON6MU
Home

50 MHz converter

RE-RXC50/10

Receive singals from the "Magic Band" on your shortwave receiver!

About the 6-meterband converter RXC50/10:

This is a very sensitive 50Mc converter allowing you to receive the entire "Magic Band" (50Mc...52Mc) on your general coverage receiver (28Mc...30Mc). It receives all types of modulated transmissions. It all depends on the receiver used. I've tested this project on a allmode Yaesu FRG-100 receiver. Within certain limits you can change the output frequency to suit your needs. The converter is very stable, low nois, sensitive and low on power consumption and can be compared to many commercial 50Mc receivers.
The heart of the converter has been built around Philips SA602 (NE602 or NE612), a twice balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 15mA. Therefore also uncomplicated usable applications fed with battery.

The SA602A is a low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator. It is intended for high performance, low power communication systems. The guaranteed parameters of the SA602A make this device particularly well suited for cellular radio applications. The mixer is a “Gilbert cell” multiplier configuration which typically provides 18dB of gain at 45MHz. The oscillator will operate to 200MHz. It can be configured as a crystal oscillator, a tuned tank oscillator, or a buffer
for an external LO. For higher frequencies the LO input may be externally driven. The noise figure at 45MHz is typically less than 5dB. The gain, intercept performance, low-power and noise characteristics make the SA602A a superior choice for high-performance battery operated equipment. It is available in an 8-lead dual in-line plastic package and an 8-lead SO (surface-mount miniature package).

50 MHz converter technical specifications

- Frequency range from 50.000 MHz to 52.000 MHz
- 50 Mc in = out 28 Mc (or 26Mc when using 24MHz LO Xtal)
- Power supply = 9...18v max
- Total power consumption = 15mA (LED included)
- Power consumption IC1 = 2,5 mA

- Sensitivity = 0.22uV at 12dB SINAD
- Mixer noise figure = 4,6dB
- Input impedance = 50 Ohm
- Output impedance = 50...600 Ohm
- Local oscillator 22MHz
- Frequency stability = +/- 5Hz
- Operating ambient temperature range = -40 to +85°C

RXC50/10 SCHEMATIC

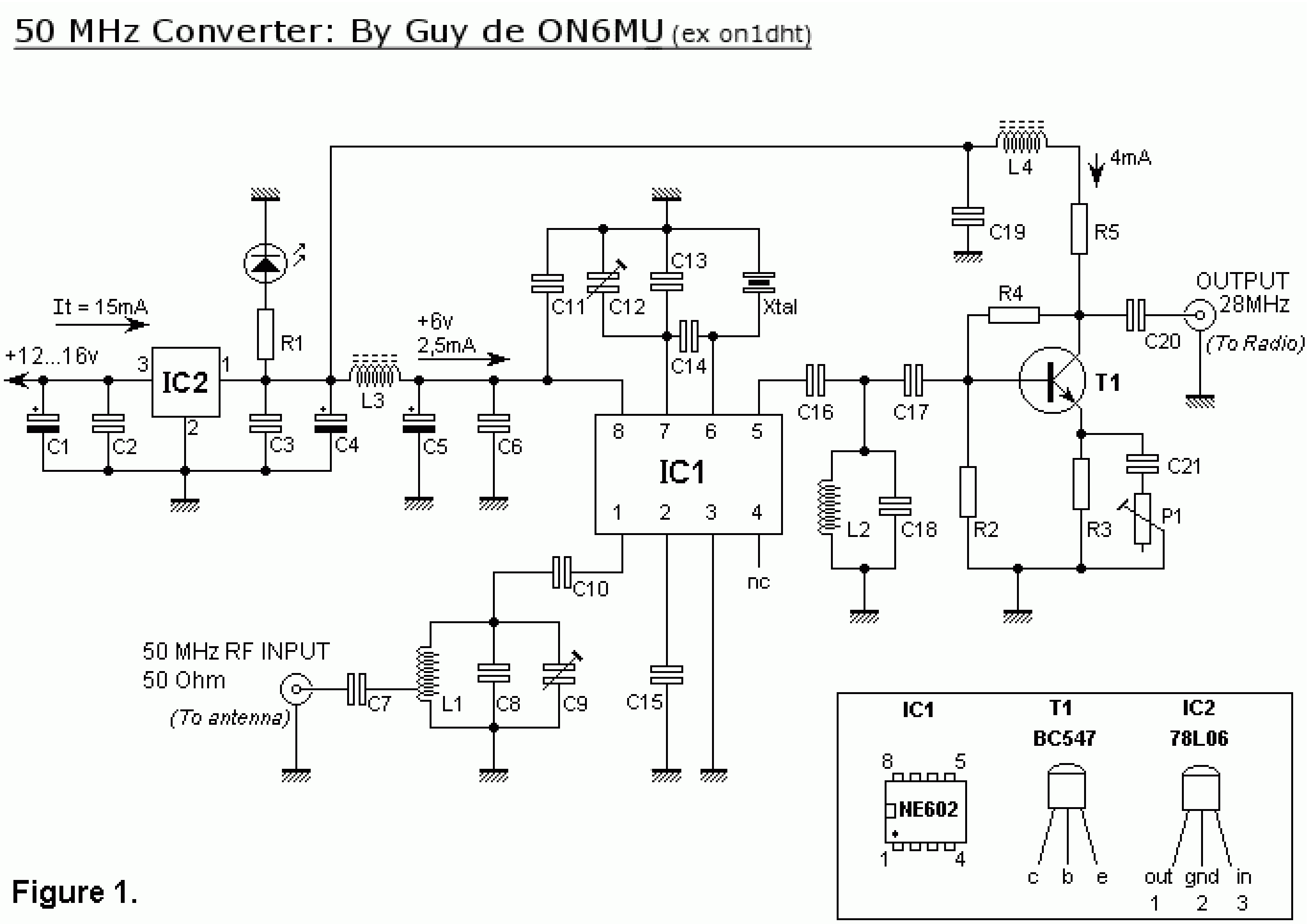


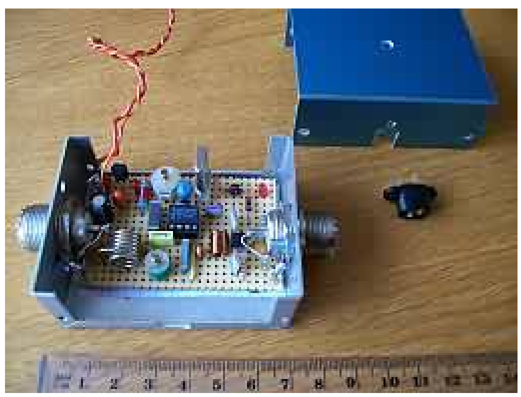
Figure 1.

PARTS

IC1 = NE602, NE612, SA602A, SA612A
IC2 = 78L06
T1 = BC547 or BC338
C1 = 10uF/25v
C2 = 100nF
C3 = 100nF
C4 = 10uF/25v
C5 = 47uF/16v (tantaal)
C6 = 47nF (polyester)
C7 = 47pF
C8 = 22pF
C9 = 0...22pF (green)
C10 = 2n2
C11= 4.7nF
C12 = 0...40pF (white)
C13 = 47pF (poly)

C14 = 39pF (poly)
C15 = 47nF (polyester)
C16 = 330pF
C17 = 330pF
C18 = 100pF*
C19 = 4.7nF
C20 = 470pF
C21 = 470pF
P1 = 100 Ohm
R1 = 1k
R2 = 2k2
R3 = 100 Ohm
R4 = 5k6
R5 = 1k
P1 = 100 Ohm

Coil specifications:
L1 = 7 wnd 1mm silver 9mm coildiameter (drill 7), tap on 1,5 wnd from the cold end.
L2 = 11 wnd 0,6mm email 5mm coildiameter (drill 4)
L3, L4 = shokes (RFC) 10uH +/- or use a ferite bead



The converter explained

The heart of the converter has been built around Philips SA602 (NE602), a double balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 15mA. Therefore also uncomplicated usable applications fed with battery.
The mixer is Gilbert cell tip quadrant configuration which 18dB can provide conversion gain. The built in Local oscillator work to maximum 200MHz tank oscillator coordinated with a high Q or crystal oscillator. The highest frequency which we can bring to the input of this IC amounts to 500MHz.
In this project we apply a crystal retrieve oscillator. Frequency stability is excellent and depends mostly of the surroundings temperature crystal then the IC itself. As it happens, a very ingenious and efficiently temperature compensating bias is built in. Important to know is that the oscillator already has an internal bias and therefore don't need extra dc-bias. Only at very high frequencies a raised direct current can be necessary. This one remedies by placing between the mass and resistor at pin 7 of a value of of 22k.
The NE602 LO works up to 200MHz and the input up to 500MHz, therefore a huge 'reserve' is available since we use a much lower LO input frequency. We want to convert, as it happens, 50MHz to 28MHz. This means therefore that we must mix with a frequency of 22MHz, meaning 50MHz - 22MHz = 28MHz output. To allow the converter to be calibrated to obtain the exact frequency, a regulable condenser of 40pF (C7) is added to the oscillator. With this you can vary the termination frequency of the converter +-300 Hz.

Without much adapting you can also use the more currently available 24MHz crystal, but then the termination frequency of the converter will be 26MHz ipv 28Mhz (24MHz LO + 26MHz OUT = 50MHz IN).
The Gilbert cell is a differential amplifier which has balanced cell feeds. The differential gives extra gain and stipulate the noise number as well as the strong indicator behaviour of the recipient/converter. And these processes values up to -199dBm with 12dB S/N ratio. The symmetrical RF input (pin 1 and 2) has internal bias, thus we avoid external DC bias (to see C10 and C15)! THE RF input amount to capacitantie 3pF. There we connect single-ended coordinated LC-kring with parallel a resonance a frequency of 50MHz. These can peaked to best reception with C9. This is done best on a frequency where we want best sensitivity, for example 50,220 MHz. To start, move C9 in the middle position. When we have wound the coil L1 correctly, C9 does not need much to be adjusted. If there is no station to tune in to, then regulate C9 till you hear maximum noise.
To have a 50 ohm input by means of C7 and a tap at 1.5 turns from the cold end of the coil. Of course you'll need on 50MHz tuned antenna too HI.
The sensitivity of the converter amounts to 0.22uV at 12dB SINAD. Third-order the intercept point is -13dBm. This is approximately +5dBm output interception because of the RF gain.
The mixer has an internal DC-bias, by means of we connected the output (pin 4 and 5) with a 1k5 resitor to Vcc. Disengaging of the bias happens by means of C16, since we exploit here only a single termination instead of a balanced output. A balanced output will improve something, but to keep the schematic diagram simple, I have not applied this.
To allow only the 28Mc signal to pass through to T1 and into your radio I added a bandpass filter made out of C16,C17,L2 and C18. How crazy it may sound it actually improved the gain too.
The termination capacitance of the mixer (pin 5) amounts to 1.5kOhm. Given the termination indicator and the RF output voltage is a bit on the low side to connect directly to the recipient (radio), there is a amplified step to added which exists from a single BC547 transistor and als serves s a buffer between your receiver and NE602. With P1 one regulates the termination level (amplification) of the converter according to the entrance sensitivity of your communication receiver. The ideal setting is when we have the best singla/noise ratio. For the most the centre setting of P1 should be sufficient. An signal/noise ratio improvement can be made by using dual-gate mosfet ipv BC547(or BC338). The noise number of SA/NE602 is 4,6dB at 20°C and T1 ads its own noise level to it, as a result we end up with an average noise number of approximately 5dB.

C18 and L2 acts like a bandpass in this schematic. It passes signals approx. 26...30MHz. If using another LO frequency it could be needed to tweak C18. So it isn't a bad idea to uses a variable capacitor (trimmer) to fine tune the bandpass in this case.

More about the SA602 (NE602, SA612) in this project

The SA602A is a Gilbert cell, an oscillator/buffer, and a temperature compensated bias network as shown in the equivalent circuit. The Gilbert cell is a differential amplifier (Pins 1 and 2) which drives a balanced switching cell. The differential input stage provides gain and determines the noise figure and signal handling performance of the system.
The SA602A is designed for optimum low power performance. When used with the SA604 as a 45MHz cellular radio second IF and demodulator, the SA602A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -13dBm (that is approximately +5dBm output intercept because of the RF

gain).
Besides excellent low power performance well into VHF, the SA602A is designed to be flexible. The input, RF mixer output and oscillator ports can support a variety of configurations provided the designer understands certain constraints, which will be explained here.
The RF inputs (Pins 1 and 2) are biased internally. They are symmetrical. The equivalent AC input impedance is approximately 1.5k || 3pF through 50MHz. Pins 1 and 2 can be used interchangeably, but they should not be DC biased externally.
The oscillator is capable of sustaining oscillation beyond 200MHz in crystal or tuned tank configurations. The upper limit of operation is determined by tank “Q” and required drive levels. The higher the “Q” of the tank or the smaller the required drive, the higher the permissible oscillation frequency. If the required LO is beyond oscillation limits, or the system calls for an external LO, the external signal can be injected at Pin 6 through a DC blocking capacitor.
External LO should be at least 200mVP-P. It is important to buffer the output of this circuit to assure that switching spikes from the first counter or prescaler do not end up in the oscillator spectrum. The dual-gate MOSFET provides optimum isolation with low current. The FET offers good isolation, simplicity, and low current, while the bipolar transistors provide the simple solution for non-critical applications. The resistive divider in the emitter-follower circuit should be chosen to provide the minimum input signal which will assure correct system operation.

Notes:
Tune to the desired bandpass frequency (50Mc) with C9 until you have the best reception.
Use C12 to calibrate the output frequency to your receiver. The output frequency can be adjusted up to 300Hz.
The output HF-level can be adjusted with P1. Regulate it according to the sensitivity of your receiver.

Other output frequencies can be set by changing the 22MHz Xtal: Example: output frequency is 26 MHz then you use a 24 MHz Xtal (50MHz - 24MHz = 26MHz).
Build the converter in a metal box and use small connections between the parts.

Important: use only a antenna designed for 50MHz! A simple dipole of around 3 meters in length (two times 1,45 meters) will work just fine if the propagation is there. Look at my homebrew site for a 3-element beam that works much better then a dipole and gives more gain, or a my 1/2 lambda vertical antenna.

More info about the 50MHz band (6 meters, the Magic band...) can be found at my site at MagicBand or Radioamateur Info.

PCB:
A PCB has been designed for this project by ON1MFW. E-mail me for detailed high resolution image of the PCB. Example: PCB-parts side PCB layout

Detailed information and manual (in Flemish (Nederlands)) ON6MU's 50MC CONCVERTER MANUAL

Technical graphs:

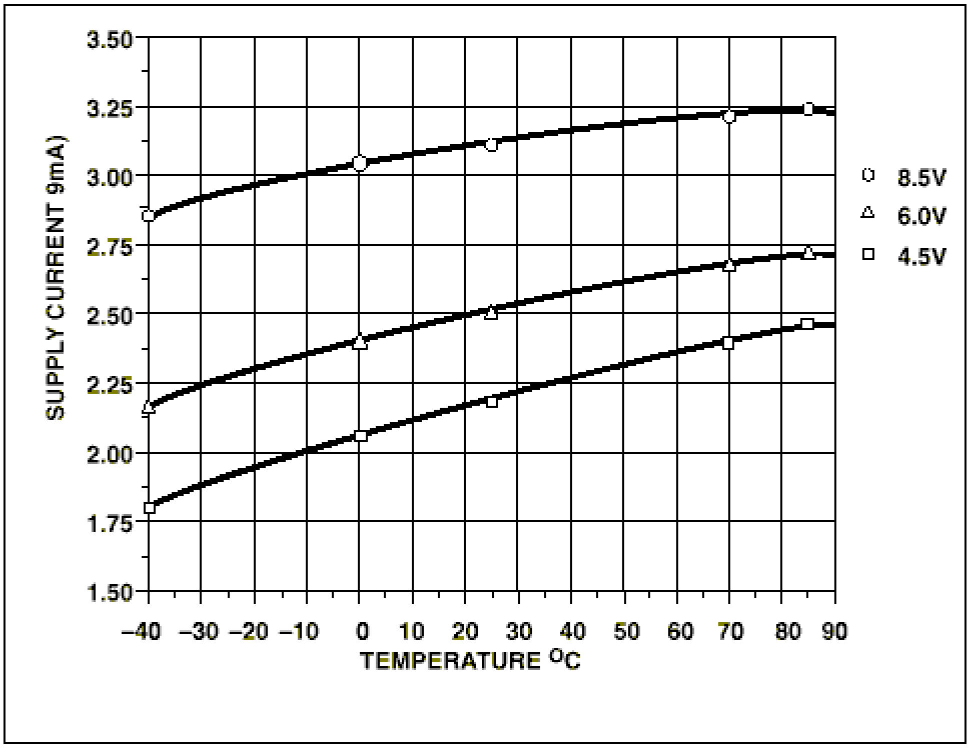


Figure 2. I_{CC} vs Supply Voltage

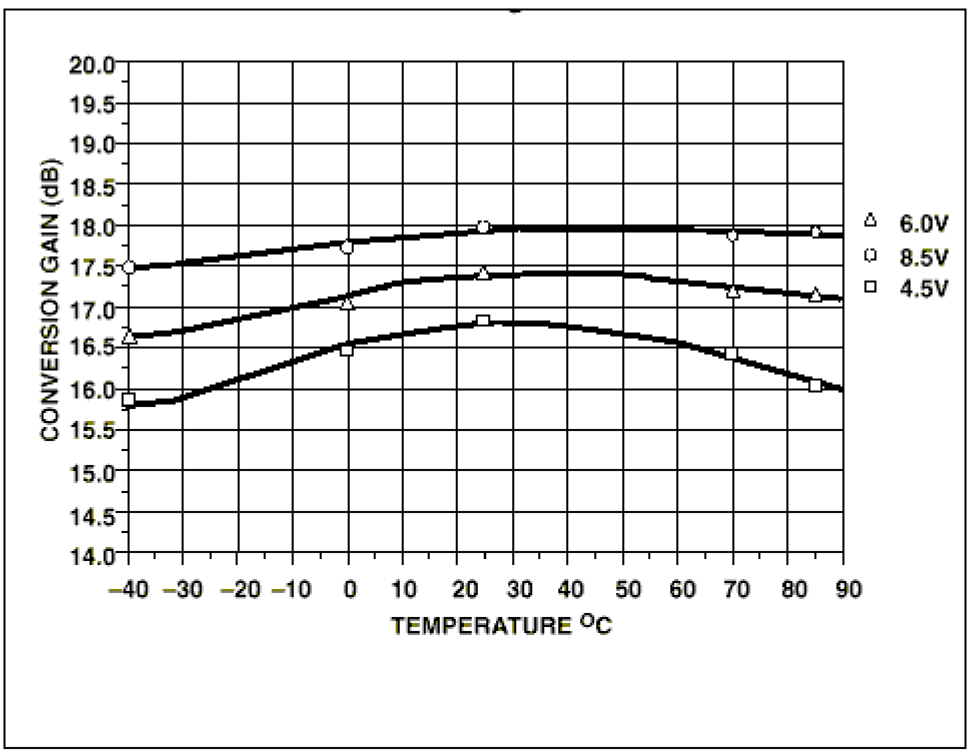


Figure 3 . Conversion Gain vs Supply Voltage

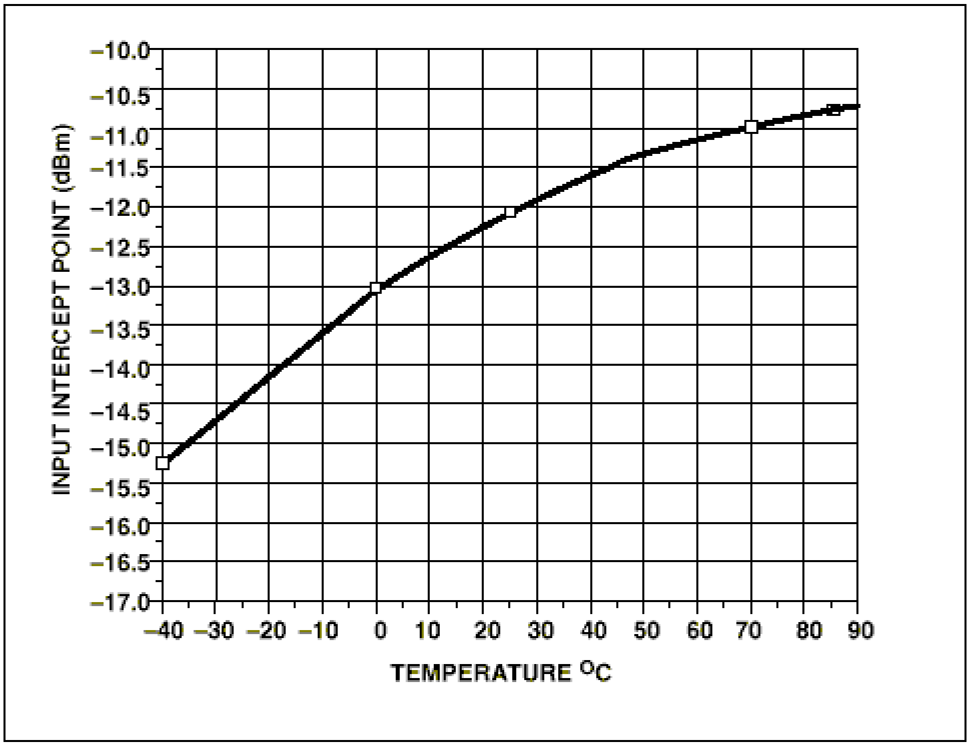


Figure 4. Third-Order Intercept Point

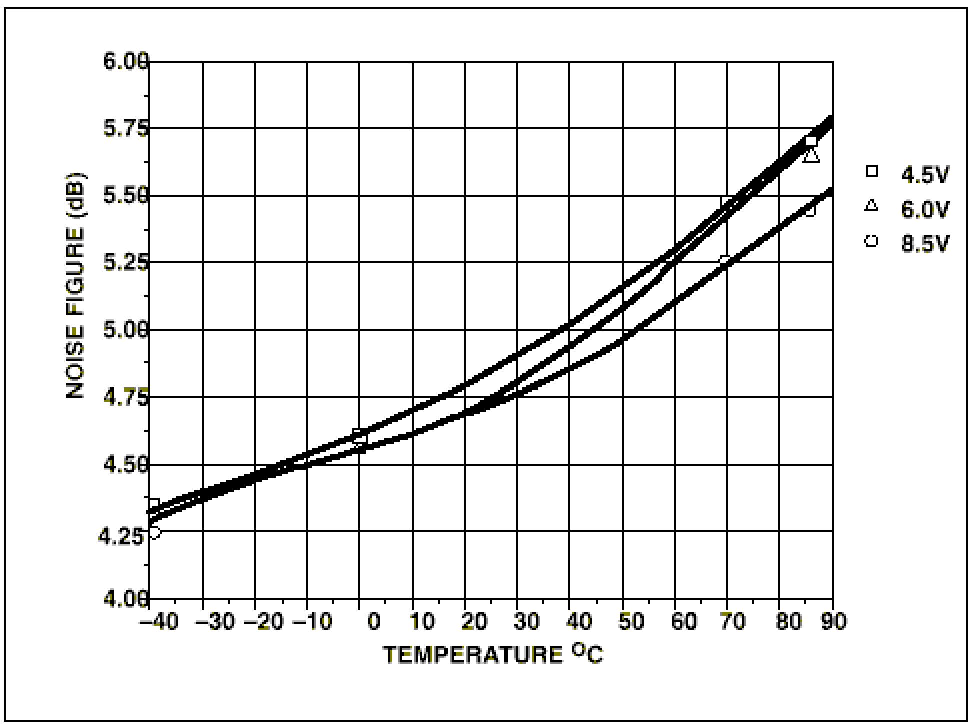


Figure 5. Noise Figure

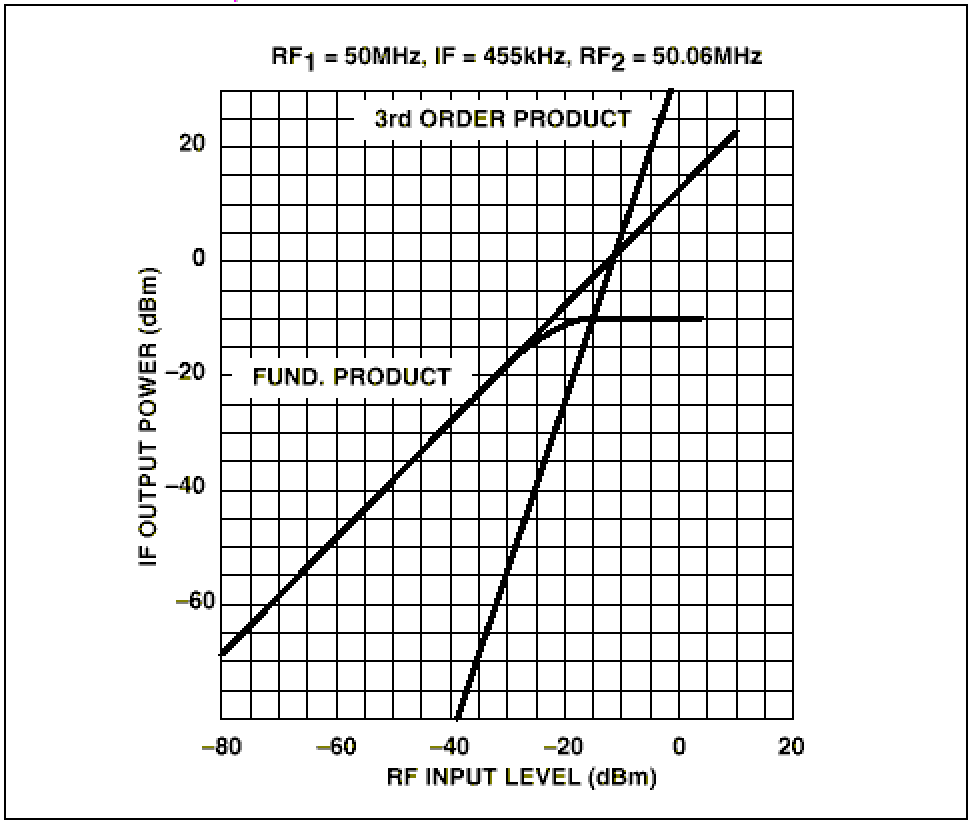
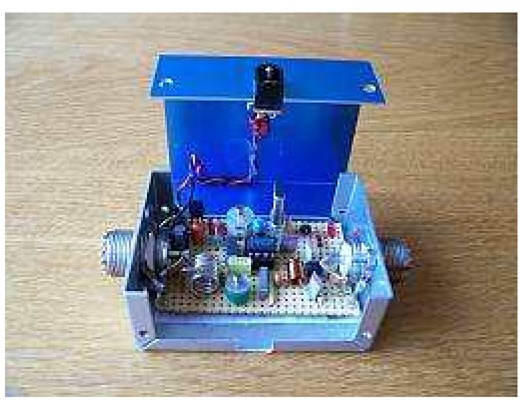


Figure 6. Third-Order Intercept and Compression

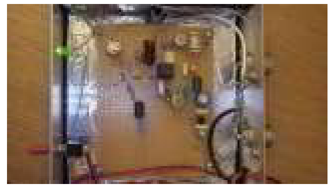
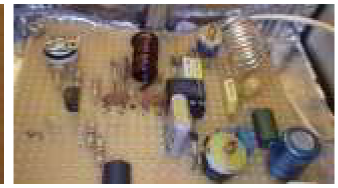
This project has been published in CQ-QSO (in Dutch and French) the ham-radio magazine of the UBA. Magazine 06-07/2000 pages 14,15,16 and 17.

[Afdrukken van dit project]

More about his:



How Geoffrey F4FVI made it:

Thanks Geoffrey for the pictures!

My E-mail

Note: if you want to commercialise, publish or distribute this project then you need to ask permission to do so.

[home]

[mail] [shack] [homebrew] [software] [satellite] [haminfo] [mods]

Back to ON6MU **Homepage**

ON6MU
Project Condor16
VHF transceiver

By Guy, de ON6MU
revision 1

Links

- Ombouw Condor 16 - 164->145MHz (PA0NHC)
- Teletron Condor 16 (PA3EKI)
- Condor16 manual en mods

Condor16 mod specificaties

- VHF RX: 140...154Mc +- (afhankelijk van de gebruikte eprom)
  VHF TX: 144-146Mc (afhankelijk van de gebruikte eprom)
- Modulatie: PM of FM (na mod)
- Vermogen: 1 of 10 watt
- 2 VCO's
- Werkspanning: 11...14volt negatief geaard
- Verbruik: 500mA @ 13,8v RX
  ....: 1,7A @ 13,8v bij 1 watt TX
  ....: 3,5A @ 13,8v bij 10 watt TX
- Frequentie- of kanaaluitlezing
- Antenneconnector: BNC
- Uit- en ingangsconnector: DB15 connector
- 1750Hz
- CTCSS
- SELCALL
- Scan
- Grid adjustable at 10.0, 12.5, 20.0 and 25.0kHz
- -0.6Mc repeatershift
- Backup memory + - 30 minutes
  - Specs after standard mods:
  - VHF (2-meter band) capable
  - FSK output (48kc) on DB15 connector pin 5
  - Scan processor mod
  - S-meter out on DB15 connector pin 13; (interrupted on print)
  - ...
  - Specs after my mods:
  - * Extended backup memory with 1000uF: 60 hours + -
  - * 3.5mm speaker output connector
  - * 3.5mm FSK wideband LF output connector

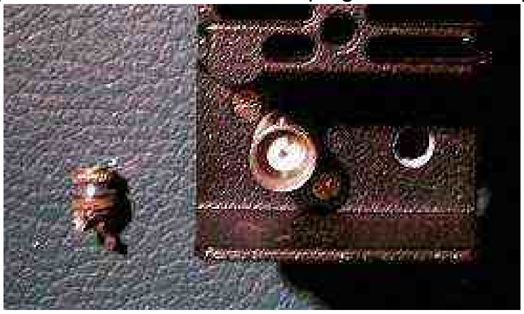
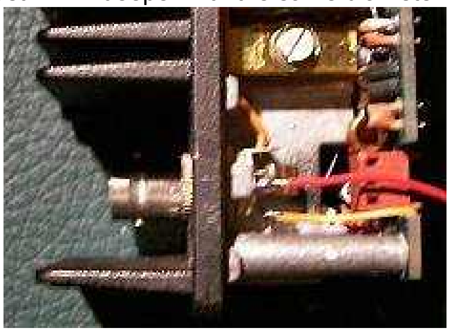
  - * Reverse polarity protection
  - * Built-in modulation preamplifier: direct connection of dynamic microphone
  - * Built-in mini speaker
  - * S-indicator LED
  - * 4 pin microphone connector with LF output (also for packet)
  - * Key covers with the new functions

Manual

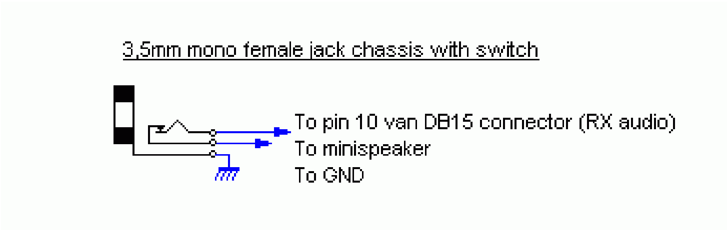
- Click here for the Condor16 manual

Modifications

- 3.5mm speaker output connector
- Built-in mini speaker
- Built-in modulation preamplifier: direct connection of dynamic microphone
- S-indicator LED
- 4 pin microphone connector with LF output (also for packet)
- 3.5mm FSK wideband LF output connector
- Reverse polarity protection
- Extended backup memory with 1000uF: 50 hours + -
- Keyboard covers with the new functions

1. Output
   connector for external loudspeaker: Although I have built in a mini speaker, I still wanted to connect a - much better - external speaker. Use a 3.5mm mono plug with switch so you can switch off the built-in speaker when using the external one.
   
   Underneath the BNC antenna connector there is a recess that you only need to drill through in order to place the correct diameter for the loudspeaker plug. At the back there is just enough space to mount and connect it. However, with many 3.5mm jack chassis connectors, the length is too short to be able to project through the rather thick back plate. To correct this, drill just 1 mm deeper with the same diameter as the 3.5 mm screw, so that the screw is slightly sunken.
   
   The mass can easily be connected directly (see orange wire) and since the chassis is also on the ground you have a good gnd.
   The audio branch is also on the same print, namely pin 10 of the 15DB connector on the TX print.

Finally, you feed a wire from the switch of the 3.5 mm connector inwards to connect the mini built-in speaker.



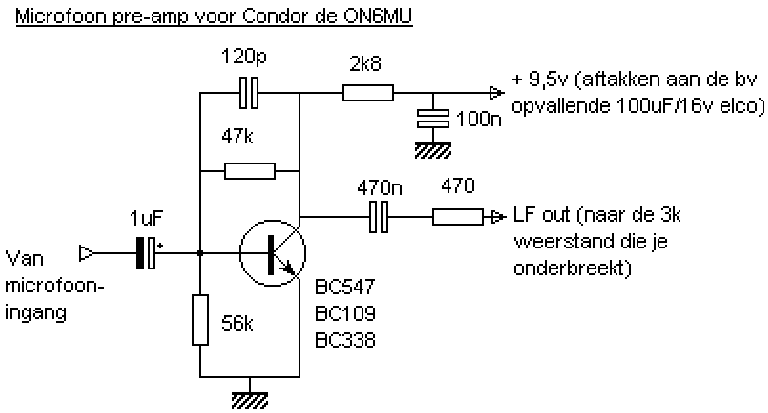
2. [Built-in miniature](#)
   speaker There is unfortunately too little space for installing even the smallest "normal" loudspeakers, as you can find them in those small AM radios. But, there are speakers that are even smaller, and especially much flatter; the ones that are used in eg portables, mobile phones etc. A good electronics business will certainly have some types of miniature speakers. I have been able to purchase a mini speaker from just 25mm diameter and about 6mm high. I attached it with some double-sided self-adhesive tape to the only place that is left in a Condor, namely:

   yep, here HI

   Then exactly measure where the speaker openings must be located and you can drill a few holes as the picture below demonstrates:

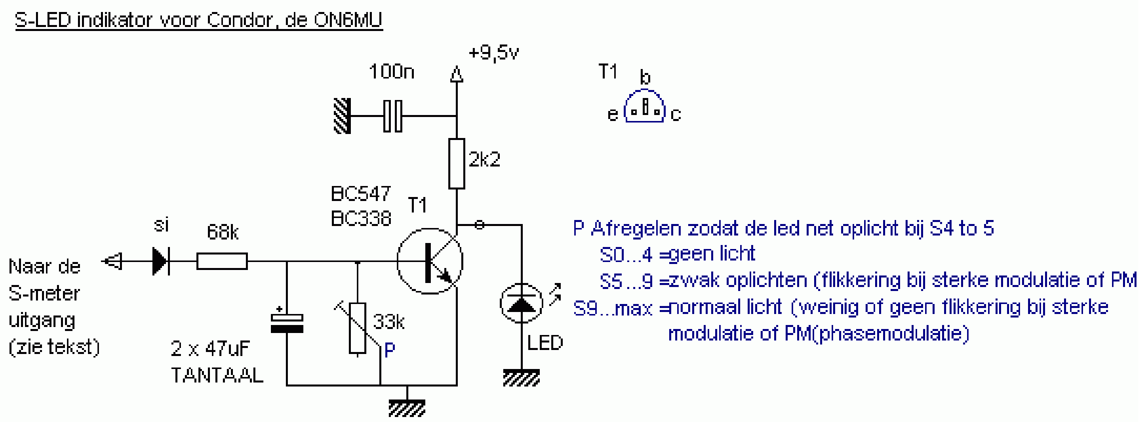
   You would be amazed how "loud" and still a pretty nice "timbre" can create such a small speaker. Usually those little speakers are limited in power. To protect this somewhat against the maximum audio power of Condor, you should install a 1 / 2watt 6.8 Ohm resistor in series with the loudspeaker.
3. [Diagram 1: Microphone LF Amplifier](#)
   A Condor needs a considerably pre-amplified microphone to achieve the necessary modulation level. Unfortunately, a "standard" dynamic microphone without amplification can not simply be connected. To solve this I have designed the diagram below. This is a simple GES with sufficient gain to connect a dynamic microphone element. There is also a small audio correction to reduce the high and the low what to boost. The typical "sharper" modulation of the Condor has largely been remedied.



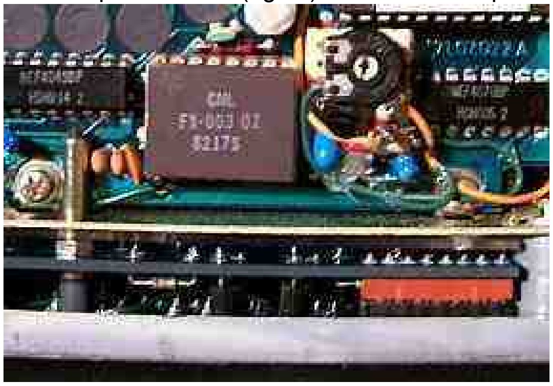
Make the circuit as small as possible and pay particular attention to the height of the components! With some skill and small components you can put it on a 10mmx15mm print. This is important, because there is not much place there, HI.
The connection of the microphone input and the audio output can be found on the middle print in the upper right corner (where the audio pot is located.) By the way, the modulation depth is adjusted with the same pot). Interrupt the small 3k resistor just below the connection pins (see photo) and use the released solder pads of that resistor. The output of the amplifier comes on the island closest to the audio potentiometer, the entrance or the furthest.

Attach the PCB with a glue gun and ensure that no contact can be made when you replace the top print.

4. [Scheme 2: S-indicator LED]
The Condor has no S-meter and there is no room to build one. A possible solution could be a compact four or more LED bar level meter. Of course, you can use an external high-impedance rotating coil tester (see manual).
In order to get an idea of the received signal strength somewhere, I only made a single LED S-meter. You really have to take that "S-meter" with a grain of salt (or two) of salt. Anyway, this S-LED indicator gives you an indication of the signal strength by means of the light intensity. Ok, it is very rudimentary, but you learn to "read" the light intensity and the "flickering" of the LED fairly quickly. You can adjust the S-LED indicator with the potentiometer "P". I have tuned the thing that only signals stronger than S4 start to light up the LED weakly (weak signals you recognize fairly quickly on hearing alone). If your Condor is still in phase modulation (default,
The S-meter voltage, to which you connect the following circuit, is on the low-pass filter after the squelch detector (see manual for details).



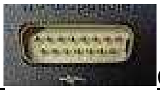
Important: do not use an electrolytic capacitor instead of the 2 x 47uF 10v (or 100uF) tantalum! The purpose of the tantalum elco is to reduce the "flickering" that occurs during the (strong) modulation of the station received (Mode PM).
You also have to build this small picture very small and not too high. So think about the components used, because here too there is not much space free HI (again). There is still a place available on the top print next to the FX-003 IC.

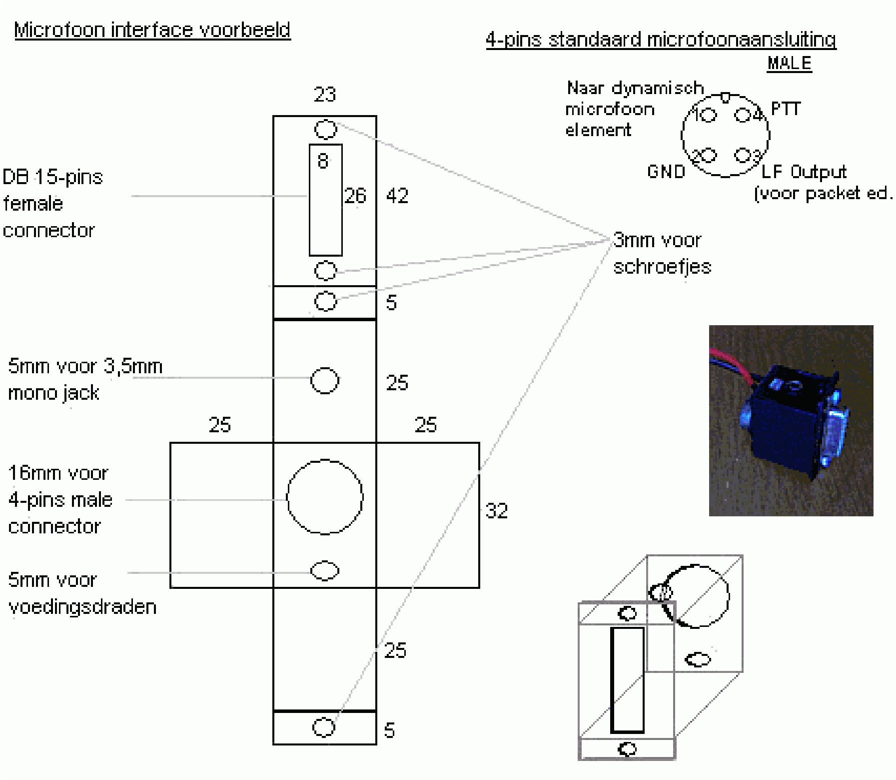


As an S-LED, I replaced the front LED (just next to the volume knob). With one wire you can connect it to the above diagram and the mass branch somewhere on the display print. You can also - like me - use one of the free pins of the display unit connector. Two are not connected. Ie connected to the print but not to the display unit. You can then interrupt one pen and connect the S-LED output to it and on the display unit you make a female pen that you fix with glue exactly at the height of that particular pen.

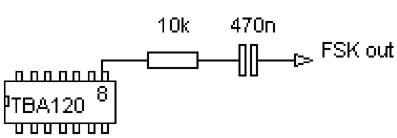
5. Microphone interface: 4-pin microphone connector, also for 1k2 packet / sstv

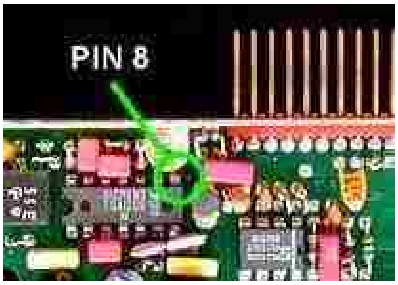
To keep everything as compact and mobile as possible, I made a "microphone interface connector". The primary aim was to connect a standard dynamic microphone directly to the condor AND to use the same connections for packet and sstv. A 4-pin connection is already sufficient to realize this idea. There is also a connection in this "box" for the FSK-discriminator output (for example 9k6, see condor connection below) and of course the power connection. For the latter, a simple polarity protection has been built in

Condor DB15 connection "to the outside world"  Cabinet Microphone interface finished and connected to the Condor:



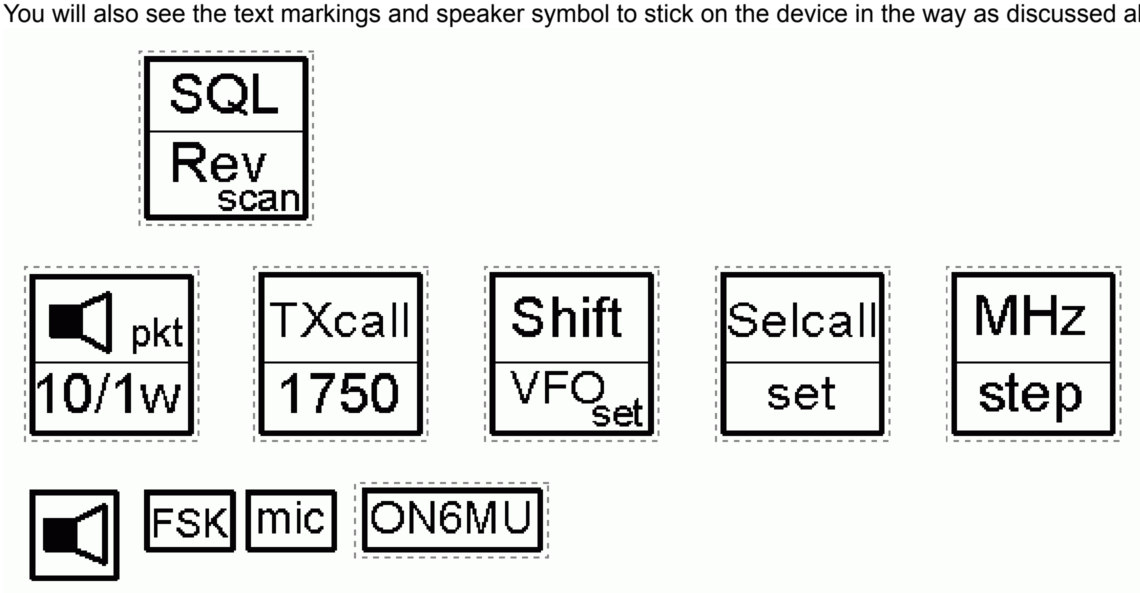
6. [FSK wideband output (discriminator signal)]() FSK wideband output is also housed in the same microphone interface and can be connected in the following way: Pin 8 of the TBA120S on the middle PCB in the Condor: At pin 8 of the TBA120 a resistor of 10 kilo-ohm mounted in series with a 470nF capacitor and thus connected to the outside world. There is no need to drill to provide an additional connector for the discriminator signal. Pin 5 of the 15-pole D-connector on the back of the Condor is unused. It is perfectly possible to use this pen to bring out the unfiltered audio signal from the discriminator IC.





7. Extended memory backup
An alternative and cheaper way to extend the memory retention time when turning off the transceiver is a 1000 ... 2200uF 6.3v electrolytic capacitor. This is placed between pin 40 of the 80C39 and the ground (see manual). With a 1000uF / 6.3v elco one soon has more than 60 hours of backup instead of a few minutes.

8. Keyboard covers
To increase the different functions of the eprom and the ease of use, I made the following test covers. You can then print it, plasticify it and then apply it, for example, using double-sided tape or, if necessary, glue it.
You will also see the text markings and speaker symbol to stick on the device in the way as discussed above.



9. **Links of interest:**
. **ON6MU Homebrew projects** . Radio amateur related projects . **ON6MU Ham mods** . Modifications or transceivers

73 "and have fun with the project!
Guy

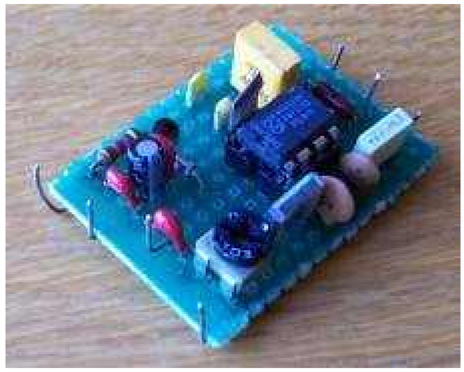
ON6MU

Home

DRM
MF 455kHz -> AF Converter
RE-RXC0455/0012

(455kHz down converter)

MFC revision 1.4



MF (455kHz) to AF (audio frequency) Converter/Interface
to receive DRM singals your shortwave receiver, like the Yaesu FRG-100!
and FT-817/897

Please take also look at our Digital Analog Demodulation Project (DADP, VE7DXW)

Attention! The modification will be done at your own risk!

About the MF-LF converter/mixer RXC455/0012:

This is a very sensitive homemade MF converter/interface allowing you to receive the DRM radio (Digital Radio Mondiale) with your general coverage receiver and a soundcard. It can also be used for software radio apllications, and other MF to LF experiments (not just DRM, and surely not just for the Yaesu FRG-100)!
I've tested this project on a allmode Yaesu FRG-100 receiver. Within certain limits you can change the output bandwidth frequency to suit your needs. The converter is very stable, low noise, sensitive and low on power consumption.
The heart of the converter has been built around Philips SA602 (NE602, NE612, SA612), a twice balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 13mA. Therefore also uncomplicated usable applications fed with battery if needed, but in this converter's DRM application I use the voltage of the receiver itself.

The SA602A is a low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator. It is intended for high performance, low power communication systems. The guaranteed parameters of the SA602A make this device particularly well suited for cellular radio applications. The mixer is a “Gilbert cell” multiplier configuration which typically provides 18dB of gain at 45MHz. The oscillator will operate to 200MHz. It can be configured as a

crystal oscillator, a tuned tank oscillator, or a buffer
for an external LO. For higher frequencies the LO input may be externally driven. The noise figure at 45MHz is typically less than 5dB. The gain, intercept performance, low-power and noise characteristics make the SA602A a superior choice for high-performance battery operated equipment. It is available in an 8-lead dual in-line plastic package and an 8-lead SO (surface-mount miniature package).

Revision 1.1(June 09)
I have added a low noise transistor (Q1) to amplify the output to a more convenient level, as I noticed that the audio level was just below the ideal level on one PC, whilest on my laptop the level was enough. Remember to set the ideal audio volume level if needed from within your OS. R4 (already existing in rev.v1.0) and C13 gives some additional filtering of the LF signal.

Revision 1.2(Nov 09)
I have noticed that by adding C17 hence limiting the highest frequency responce and amplifying the lower 5...20kC gave additional improvement.
P (trim pot) of 2k5 to allow exact LF output level setting for your soundcard input
Voltage for Q1 now also 6 volt (tapped from IC2)

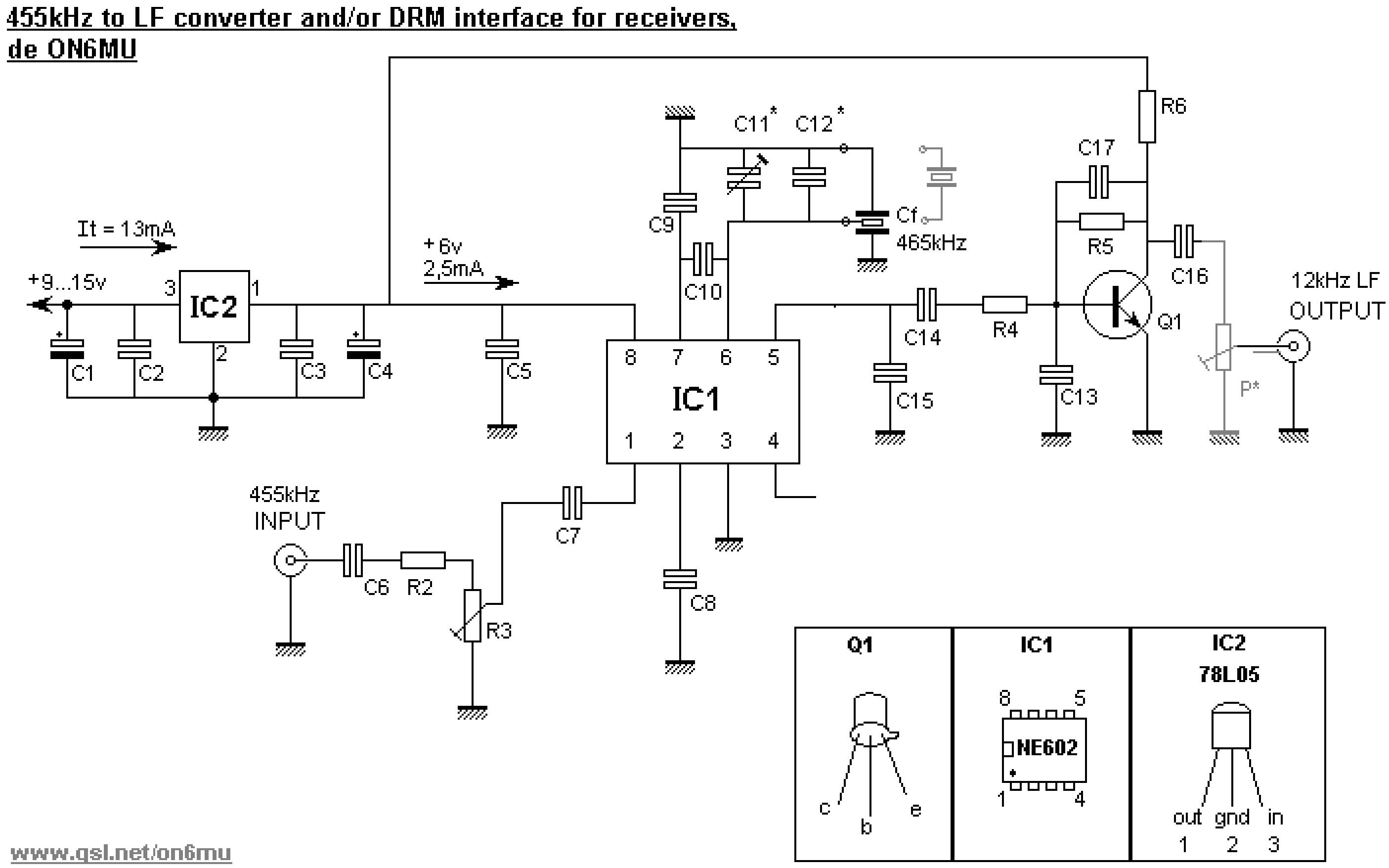
Revision 1.3b(Nov, 21th 09)
C19 & C18 added as it gave a noticable cleaner signal but lower LF output
R7 removed to compensate lower LF output
v1.3b: C18 added

Revision 1.4(Nov 14)
Changed the extractionpoint from the FRG
Some components left out to simplify the project further

RXC0455/0012 455KHz converter technical specifications

- Frequency range from 455kHz...467kHz
- LF/AF out 100...12kHz
- Power supply = 9...18v max
- Total power consumption = 13mA
- Power consumption IC1 = 2,5 mA
- Sensitivity = 0.22uV at 12dB SINAD
- Mixer noise figure = 4,6dB
- Input impedance = 3k
- Output impedance = 1k
- Local oscillator 467kHz
- Frequency stability = +/- 5Hz
- Operating ambient temperature range = -40 to +85°C

RXC0455/0012 SCHEMATIC



PARTS

IC1 = NE602/SA602 or NE612/SA612 (all pin compatible)
IC2 = 78L06
Q1 = BC109,BC107
C1, C4 = 2.2uF/25v
C2, C3 = 100nF
C5 = 470pF
C6 = 100nF(polyester)
C7 = 68nF (polyester)
C8 = 100nF
C9 = 1nF
C10 = 820pF
C11= 100pF trimmer
C12 = 220pF
C13 = 1n5 (poly) *v1.1*
C14 = 220nF (polyester)
C15 = 2n2 (mylar,poly)
C16 = 220nF (poly) *v1.1*
C17 = 120pF *v1.2*
Cf = 465B (ZTB465 kHz, or 470kHz) ceramic filter resonator
R1*= 10k (not specified in the schematic, see text)
R2 = 1k8
R3 = 10k
R4 = 1k
R5 = 100k (*v1.1*)
R6 = 2k2 *(v1.1)*
P* = 2k5 (*v1.2*)

Ceramic resonator:
Cf is a simple 465 khz ceramic filter (3 pin or 2 pin version can be used). These can sometimes be found in a AM/FM transistor radio, old wireless telephones etc.

Ideal would be a quartz version as this offers best stability and accurate resonating frequency of the mixer.
There are many out there that are not exactly on frequency! When using it for DRM the mixing frequency is not critical, so you can use a 470 kHz type too.
If the bandpass is not 12 kHz and the frequency is too high you will need to adjust the mixing frequency Cf by using C11.
If the bandpass does not reach 12kHz because of the mixing frequency being too low you will need to add a capacitor in series with the ceramic resonator Cf, something between 100pF and 300pF. I would recommend starting with 150pF (or use a trimmer).
- ceramic filters can be order [here](#) (only EU)

What's DRM

The Digital Radio Mondiale (DRM) purpose is to develop a non-proprietary technical standard for the replacement of analogue AM (Amplitude Modulation) radio with digital radio, also called DRM.

As a replacement for AM the existing channel spacing, medium and long wave 9 kHz and 10 kHz for short wave, is maintained. On medium wave a DRM radio broadcast can provide close to FM audio quality - most people will relate to the poor audio quality of AM music. With DRM the audio quality is primarily determined by the broadcast mode and spectrum occupancy (i.e. radio bandwidth of the DRM signal).

It also the displays the name of the radio station, program text, and automatic tuning to alternative frequencies will make DRM receivers easier to operate. DRM can also transmit multimedia html pages and data.

If you listen to a DRM signal on an ordinary short-wave AM radio then all you will hear is noise. There is no discernible modulation pattern when listening to DRM using a AM demodulator.
[DRM Stations recent schedule list](#)

The (DRM) converter explained using a Yaesu FRG-100

There are examples enough around which use another filter by replacing the original LF-H2S with a 12kHz or 15kHz wide filter. This allowed the user to use DRM reception by selecting the AM-narrow mode. The MF output is there tapped from the (hot) connection of VR1002 as seen from the front panel to the IF input of the converter(mixer).
In this modification I use the unused CW-filter connections hence avoiding to remove the top board and soldering/replacing the stock AMN filter. However, both methodes work.
Note: In this example DRM-mode is selected by selecting CW/N mode on your FRG-100.

Calibrating

The converter is best calibrated to fit 12 kHz wide LF output. C11 and C12 primary determines the offset of the base resonating frequency of the 465kHz filter. With a frequency counter you can check the resonating frequency which should be around 467kHz. The converter/mixer outputs 467-455=12kHz wide AF output to be fed to your PC's soundcard input.
Set C11 to get as close as possible to 467kHz. It is possible that C12 need to be changed to if the desired frequency isn't reached.
I have found that it isn't too critical, although calibrating gives the best result. However, it should work as is (set C11 to half way).
Set R3 to the best signal/noise ratio, hence also setting the maximum output of the converter.
Note:
You can add a trim pot of +/- 2k5 at the output of Q1 after C16 to set the ideal output for your soundcard input.

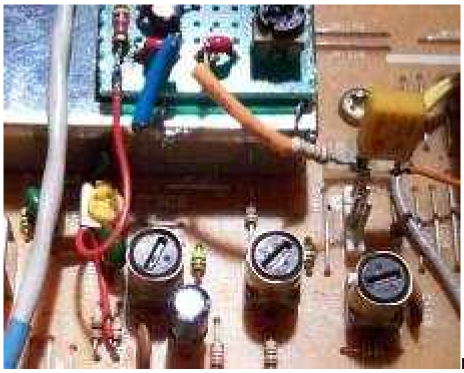
If the bandpass is not 12 kHz and the frequency is too high you will need to adjust the mixing frequency Cf by using C11.

If the bandpass does not reach 12kHz because of the mixing frequency being too low you will need to add a capacitor in series with the ceramic resonator Cf, something between 100pF and 300pF. I would recommend starting with 150pF (or use a trimmer).

Power source voltage

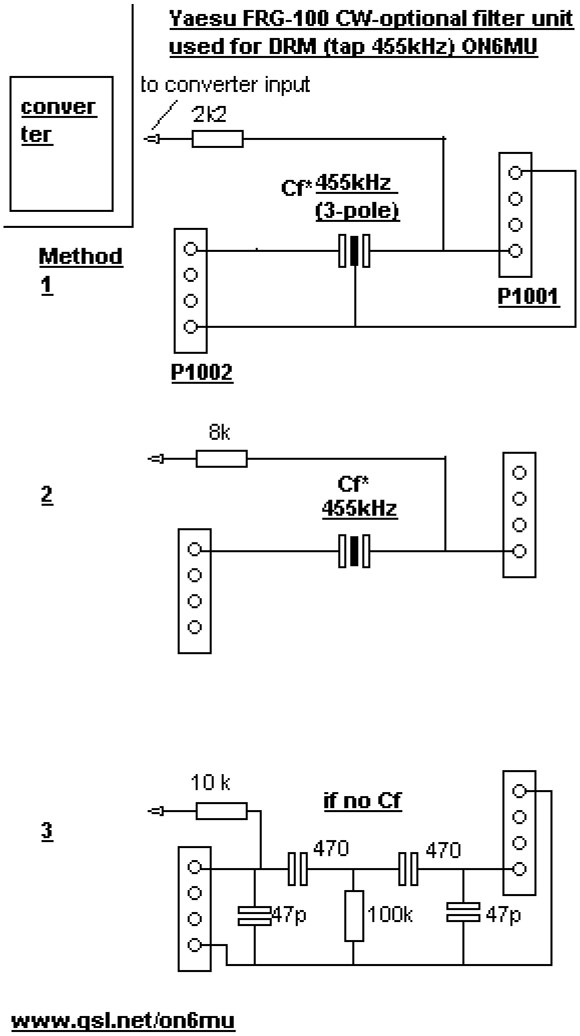
The converter Vcc voltage can be tapped from just about anywhere in the FRG-100. You can use the 12 volt input, or tap from the 9volts running allover the board. Tap often used is R1074 (closest to the front to the UB connection of the mixer board) where you find +9volt.
Any voltage from 8 to 18 volts can be fed as the converter uses a 78L06.

Using the CW/N optional filter connections


red wire is the +9v tapped from R1074, 47k resistor and ceramic filter is connected to the CW/N filter connector to get MF

It is perfectly possible to use the CW/N filter connections of the FRG-100 to tap the MF 455kHz...465Khz to feed it to our converter/mixer.

Use a 455kHz filter of 12...50kHz (often found in those old FM transistor radios etc.). This is soldered between pin 1 (top one) of CW/N filter connector P1002 and pin 4 of P1001 (bottom pin). A 47k resistor from P1002 pin 1 is fed to the input of the converter.
If you can not find such a ceramic filter (doubt it) you can replace it by a few caps (this is not a drop-in replacement, but workable enough to use for DRM with good signals till better is found).



Note: DRM-mode is selected by selecting CW/N mode.

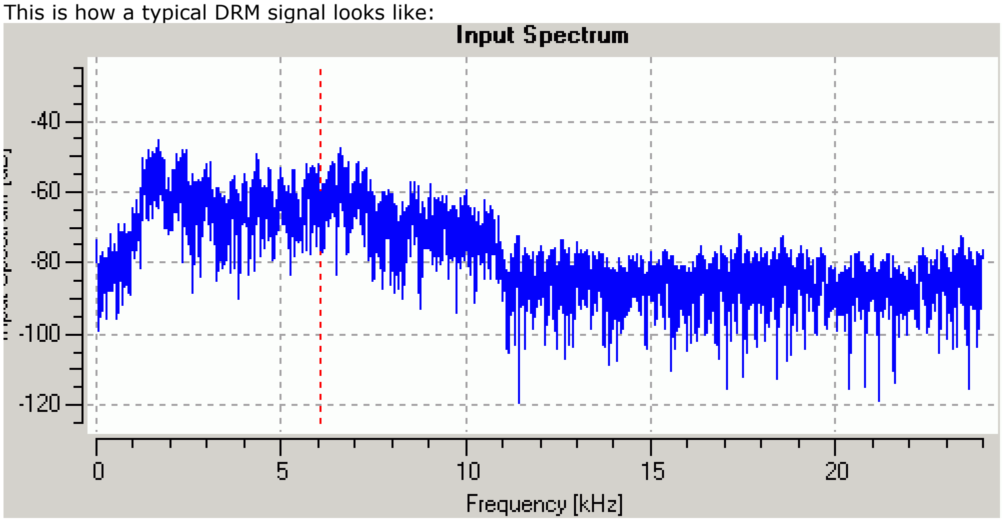
I soldered several of the converter grounds to the VFO chassis (approx. middle of the picture)
You can see the yellow/greenish 455kHz 20kc ceramic filter (between the converter and the FM-unit)
On the right side you can see my homemade FM-module based upon the Yaesu schematic found in the manual.

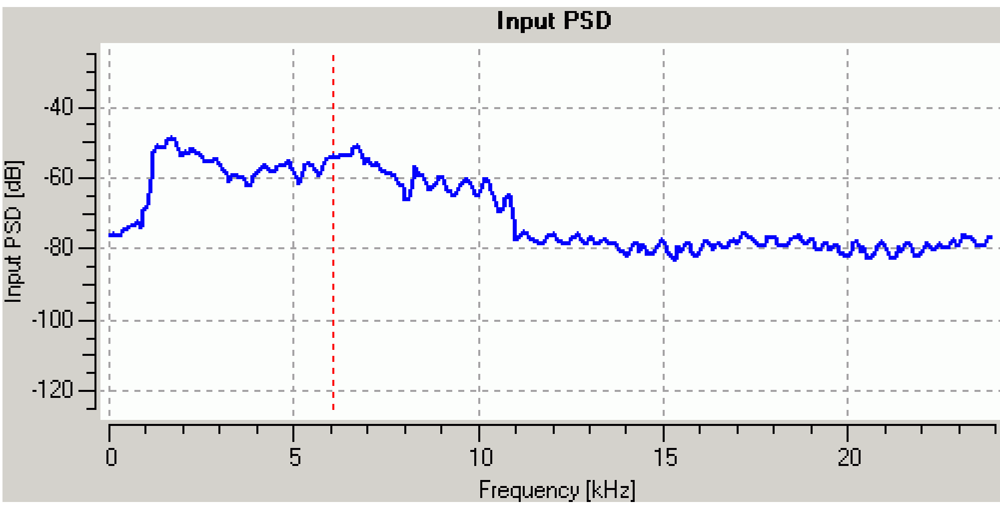
Output/tuning/setting

The output of the converter is fed to your soundcard using a female connector (on the backside of the receiver). I drilled a hole at the back of the FRG-100 to mount a 3.5mm female connector.
Use shielded wire to connect the converter to the connector.
R3 sets the maximum level of the MF signal supplied, hence adjusting R3 can improve the signal-to-noise ratio depending on the input sensitivity of your soundcard and/or do to the MF voltage

input. Set R3 to 80% to start with. Adjust the adjustment on the mixer board for a DRM-signal of approximately 50mV RMS.

This is how a typical DRM signal looks like:





- Connect the decoder software to the 12 kHz IF output of the converter.
- Set the input volume of your PC properly.
- Set your FRG-100 to CW/N mode.
- Tune to a good DRM signal (3995,5955,6095,13810Khz...).
...Note: I have found that by tuning +/- 2Kc of the DRM signal, the quality improves. Possible reason could be the sound card timing accuracy, or the LO frequency is not exact. Experiment!
...Note: To decode a DRM signal, the signal strength needs to be high and the S/N ratio has to be at least above 12dB
- Once you here the software decoding the DRM-signal you can further tweak the settings as explained above. And, the software itself has several settings that can improve the reception/decoding capabilities.

Some examples of decoded DRM signals using this converter/mixer and a Yaesu FRG100

- **Example 1a of a decoded DRM signal** - ideal reception conditions!
- **Example 1b of a decoded DRM signal** - medium ideal reception conditions!
- **Example 2 of a decoded DRM signal** - medium ideal reception conditions!
- **Example 3 of a decoded DRM signal** - bad reception conditions!

Software

DRM

Dream
http://drm.sourceforge.net
Dream - to decode DRM signals: Dream v1.16 compiled version

...The necessary Qt runtime library "qt-mt230nc.dll" can be downloaded at:
...http://prdownloads.sourceforge.net/netclipboard/qt-mt230nc.dll?download

...Optional download: AMSchedule.ini
...Get the current shortwave broadcasting schedule for AM stations from:
...http://drm.sourceforge.net/download/AMSchedule.zip

Other DRM software: http://home.arcor.de/carsten.knuetter/drm.htm
SoDiRa
..Free Software Radio (also good for DRM)
..Tip: choose in Config->Receiver->Type: DSR30
..http://www.dsp4swls.de/sodira/sodiraeng.html

WinRadio
..Commercial DRM Demodulator/Decoder for Windows 2000, XP and Vista
..Tip: Choose general-purpose DRM Software Radio (DRM demodulator/decoder for third-party receivers)
..http://www.winradio.com/home/download-drm-2.htm

SDR

H**MDSR**
HMDSR is a powerful and free SDR capabale package.
Hhomepage

H**HDSDR Homepage**:
..HDSDR is a freeware Software Defined Radio (SDR) program for Microsoft Windows 2000/XP/Vista/7/8.
..download
..*Typical applications are Radio listening, Ham Radio, SWL, Radio Astronomy, NDB-hunting and Spectrum analysis.*
..*HDSDR (former WinradHD) is an advanced version of Winrad, written by Alberto di Bene (I2PHD).*

..**SDRadio**:
..SSB, CW and AM demodulator: http://www.sdradio.eu/sdradio/
..*By I2PHD and IK2CZL, practic skin, made for für I/Q direct mixing concepts,*
..*demodulates also by set an offset of middle frequency*
..*to 12 kHz single IF very well. Can handle 40kHz+*

..**G8JCFSDR**:
..Software defined radio using MF: http://www.g8jcf.dyndns.org/g8jcfsdr/
..*By G8JCF, good AM, better SSB and CW demodulator, also software AGC.*
..*Several filter and noise reduction equipment. Also recorder mode supported.*
..http://www.g8jcf.dyndns.org/g8jcfsdr/

..**SM6LKM**:
..A Soundcard Based SAQ VLF Receiver:
..http://web.telia.com/~u33233109/saqrx/saqrx.html

..**SoDiRa**
..Free Software Radio (also good for DRM)
..http://www.dsp4swls.de/sodira/sodiraeng.html

..**SDRadio**
..I2PHD's SDRadio can be downloaded from here:
..http://www.sdradio.org/

..**IFDSP**
..IK2CZL's IFDSP can be downloaded from here:
..http://www.detomasi.it/en/project.html

DRM reception with the Yaesu FT-817

We use the optional CW or SSB Filter slot in the main unit. You must have this slot free (no optional filter) for using DRM on this radio.
The 455 KHz Signal for the DRM mixer can be easy taken from the first pin (from right) of J21 connector and connect the ground of cable to the second pin.
Now put a 455kc resonator between the first right pin of J20 and the first right pin of J21. Note:

You can use simular like used in the FRG-100 please see fig2.
If you do not have a 455kc resonator then a capacitor of +/- 120 pf will be do, but you loose the agc advantages.

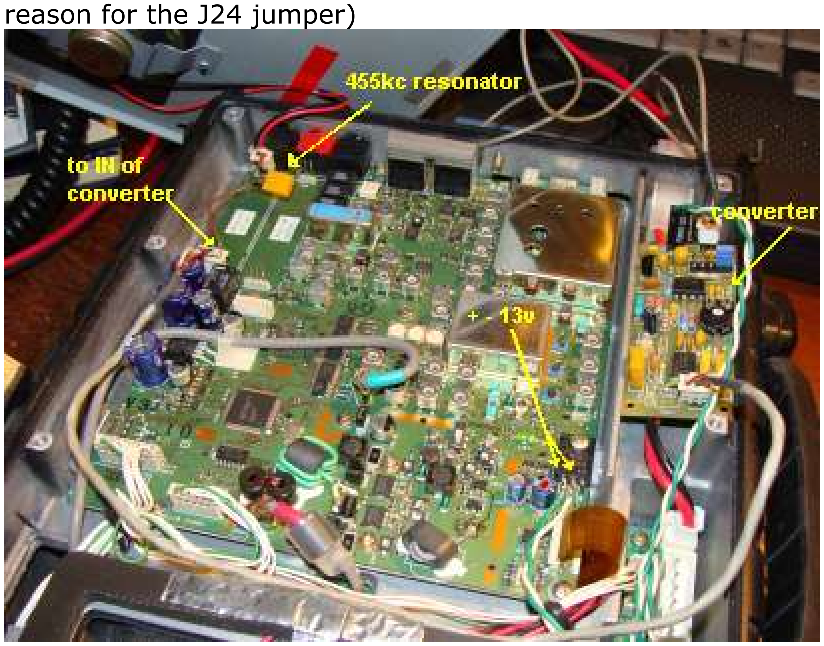
Switch on the rig and enter in the Menu System (press and hold the [F] key for on second) and choose Menu Item 38 [OP FILTER] setting mode CW.

You can activate now the DRM reception using the function NAR of the operation menu and setting CW MODE.

DRM reception with the Yaesu FT-897

Look for the slots for optional CW or SSB filter (backside, left) It’s labelled: J24 and J23.
Bridge the left two pins of J24 – so the software will use this slot as if the SSB filter is installed.
Put a 455kc resonator between the right pin of J24 and the right pin of J23. The third pin of J23 is connected to ground.
If you do not have a 455kc resonator then a capacitor of +/- 120 pf will be do, but you loose the agc advantages

Connect the DRM converter to the two right pins of J23 (ground and 455 kHz IF in).
I tapped 13 volts from the 8 volt voltage regulator (see on photo lower right corner). This connection is in consistency with the power on/off state of the rig.
For using the converter you have to enable the 2.3 kHz optional Filter setting in Menu (that’s the reason for the J24 jumper)



drm using a FT-897

Tips

* This converter can also be used to feed a LF-amplifier (listen to signals unfiltered)
* Works with some software defined radio (SDR) programs, like SDRadio from I2PHD!
* Use it to analyse wide band spectrum
* Modify the converter to allow even wider bandwidth by changing the resonating ceramic filter.
* Can of course be used by any receiver that has a 455kHz MF you can tap.

More about the SA602 (NE602,SA612,NE612,SA162) in this project

The SA602A is a Gilbert cell, an oscillator/buffer, and a temperature compensated bias network as shown in the equivalent circuit. The Gilbert cell is a differential amplifier (Pins 1 and 2) which

drives a balanced switching cell. The differential input stage provides gain and determines the noise figure and signal handling performance of the system.
The SA602A is designed for optimum low power performance. When used with the SA604 as a 45MHz cellular radio second IF and demodulator, the SA602A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -13dBm (that is approximately +5dBm output intercept because of the RF gain).
Besides excellent low power performance well into VHF, the SA602A is designed to be flexible. The input, RF mixer output and oscillator ports can support a variety of configurations provided the designer understands certain constraints, which are explained here.

[50Mc converter de ON6MU](#)
[SDRadio](#)
[FRG-100 audio improvement](#)
[Dream v1.16 compiled version](#)
[Example of a decoded DRM signal](#)

Technical graphs:

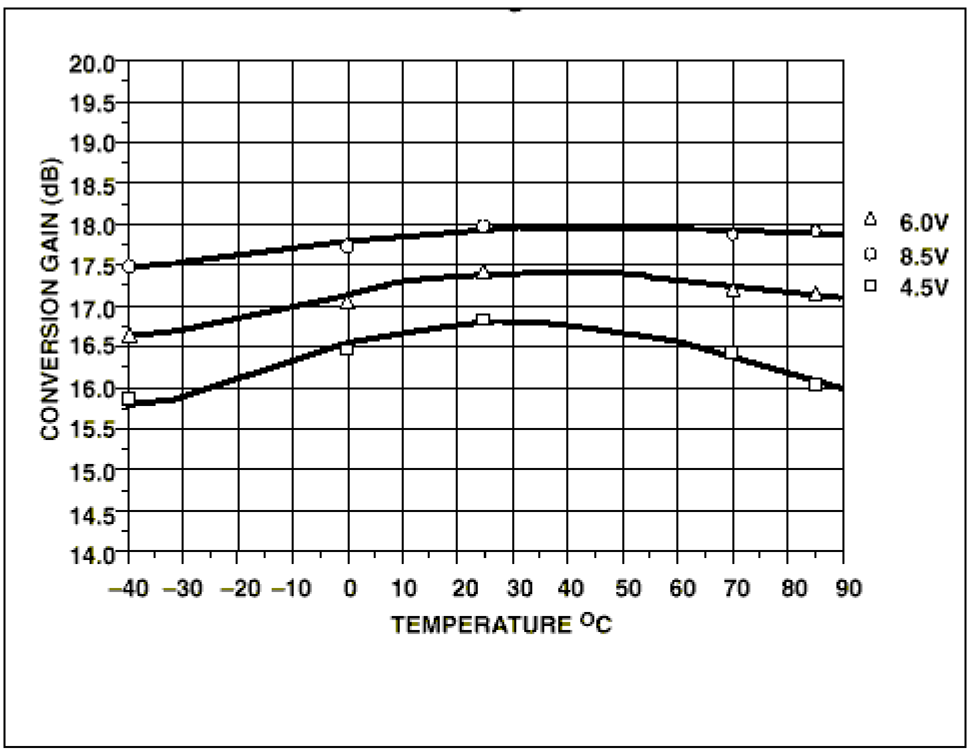


Figure 3 . Conversion Gain vs Supply Voltage

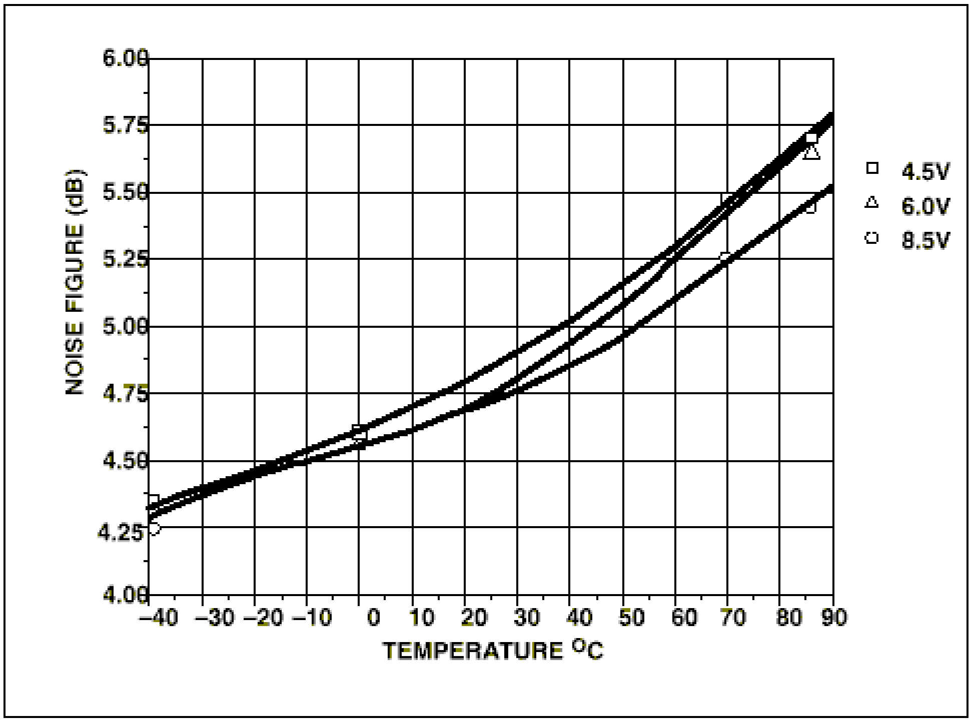
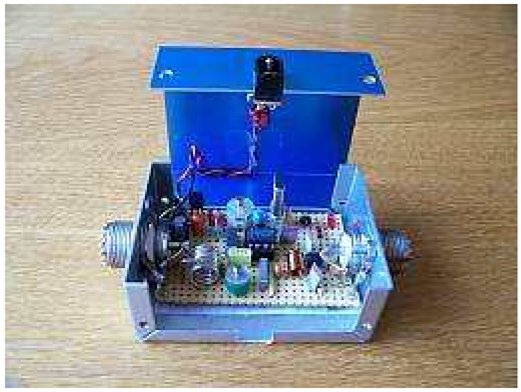


Figure 5. Noise Figure

Please also look at our [Digital Analog Demodulation Project](#) (DADP, VE7DXW) that explains in high detail how to use it for the Yaesu FT-817 and simular transceivers

More about these mods:

Youtube:
This is how Tonino IZ6QTX made it and how he is using it:
http://www.youtube.com/watch?v=VoKhKqP2duM
http://www.youtube.com/watch?v=5MvFH9X5kpU
Thank you Tonino!



Please take a look at my 50MHz converter which is ALSO based on the SA/NE 602 mixer!

50 MHz converter, 6 meter, 6-meter, 50Mc, antenna, radio amateur. Use a beam and receive distant VHF signals! using NE602 home made

---

My E-mail

Note: if you want to commercialise, publish or distribute this project then you need to ask permission to do so.

[home]

[mail] [shack] [homebrew] [software] [satellite]
[haminfo] [mods]

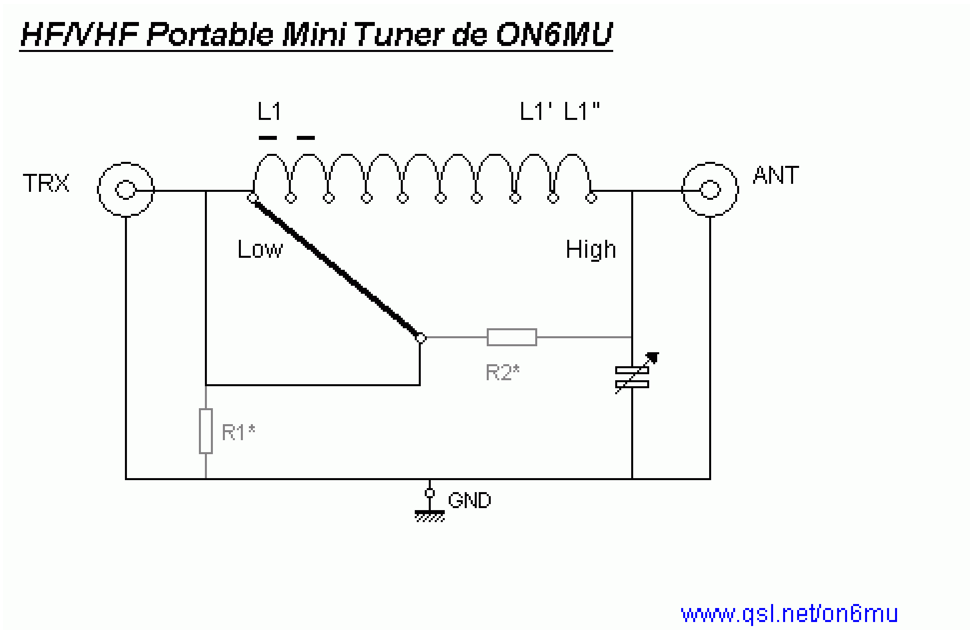
Back to ON6MU **Homepage**

ON6MU

HF/VHF Portable Mini Tuner
RE-AT2HF6/P

By Guy, de ON6MU

Schematic fig1



RE-AT2HF6/P Parts list

- alu box of 70mm X 40mm X 33mm
- 2 female PL 259 chassis
- C1 = variable capacitor of at least 300pF or better 500 pF
- S1 = 10 or more position rotary switch
- L1 = 0,7mm insulated copper wire, 6 turns par connection closely together, 9mm outside diameter (8mm inside)
  taps every 6 turns and the last two sections (L1' and L1'') 4 turns spaced at 1mm and 3turns spaced by 2 mm.
  The first two sections has a ferrite core inside.

Could be that lower frequencies needs higher inductance, experiment with by adding a core in the last few sections (see fig2)

- I added two bolts on the alu-box chassis to - if needed - connect the tuner to ground or for using a counterpoise.
- R1: 1.5k carbon 1/4w (non-inductive resistor); optional to allow drain of possible static build-up on the antenna (or use a 10mH inductor)
- R2: 2 x 470 carbon 1/2w parallel (non-inductive resistor); optional to have some little protection during switching when using a carier, as the switch could open the the connection for a fraction of a second during switching.

The coil

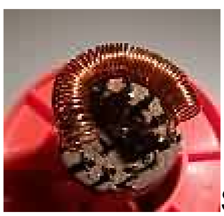
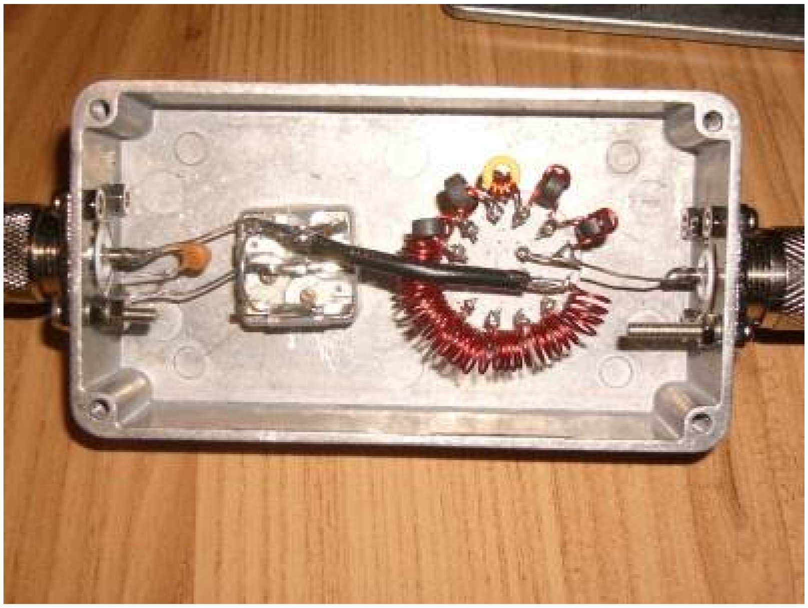
- Wind 6 turns x - 2 connections on your switch (in this project a 10-position rotary switch is used, being 8 times 6 = 48 + 4 + 3 = 55 turns) over a 7mm screwdriver (or simular obkject hi) and make a tap every connection. Solder each tap.
- Solder each tap to each connection of your switch and stretch L1' (being 4 turns) at 1mm spacing and L1''(being only 3 turns) at 2 mm spacing. You can replace L1'' by 3 turns of silver wire to allow better Q on higher frequencies (VHF).
-  Minituner insides...

Fig.2

-  *Alex VE7DXW changed 5 of the lower 6 wdg air coils with 1 wdg, 2wdg, 4wdg, 4wdg, 6wdg ferrite core coils, which gives higher L values*
  Thanks Alex!

Specifications

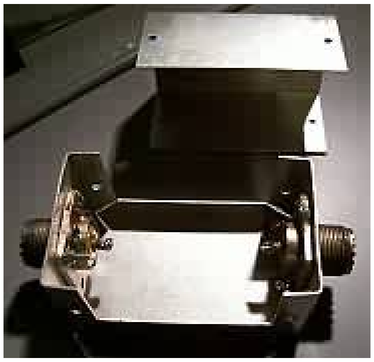
- manual operation
- frequency range (depending on the coil min & max inductance):
  160m...6m
  (Up to 150Mc if: L1" is silver(plated) wire, High Q switch, minimum capacitance of C is small enough and close connections are used in respect to 50 Ohms impedance)
- 10 Watt +-
- direct feed through
- small and compact design ideal for low power QRP transceivers, like the Yaesu FT-817, or of course for receivers...
- connection for counterpoise/ground

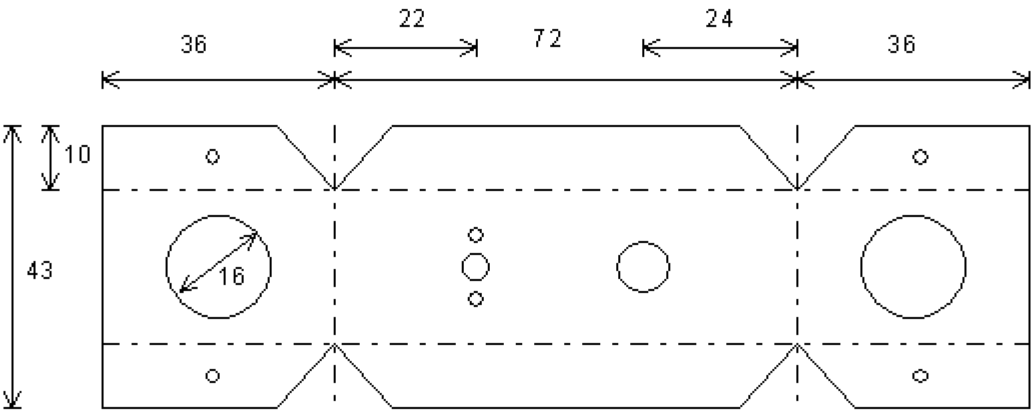
Notes:
If you elect to use an antenna tuner, it is extremely important that you understand exactly how to use tuners and what they can and cannot do. A few watts of RF can easily become lost in an incorrectly adjusted antenna matching device. The whole idea of a QRP station is to keep things simple and economical, so I cannot overemphasize the priority of a clean, efficient connection of the amplifier output to a resonant antenna.

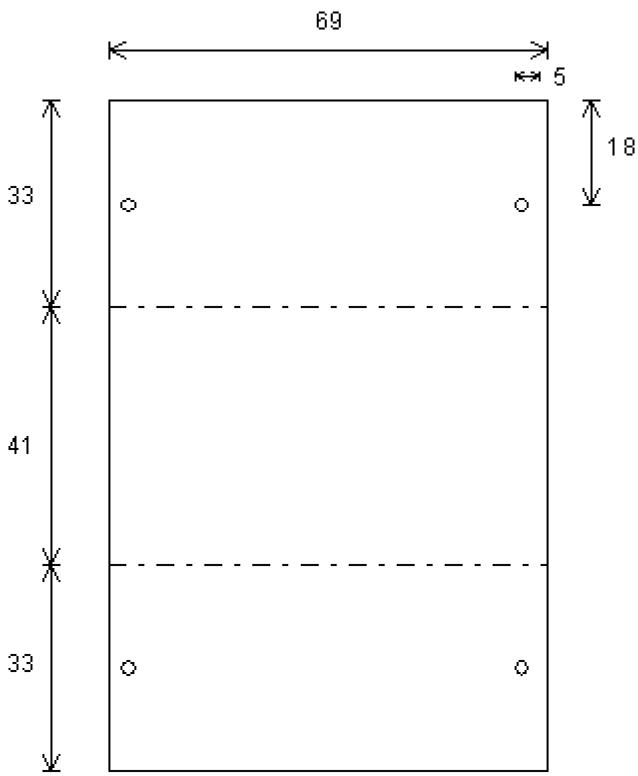
Don't forget to check these out:
ON6MU Homebrew projects
Radioamateur related projects

ON6MU Ham mods
Modifications of transceivers

Homemade aluminum box







73"

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[Home]

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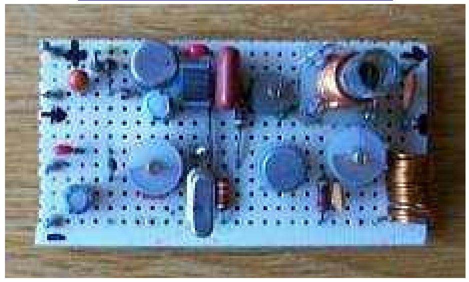
QRP AM(cw) Transmitter for the 12 meterband RE-TX02HF12



By Guy, de ON6MU

About the QRP AM / cw 12-meter band transmitter

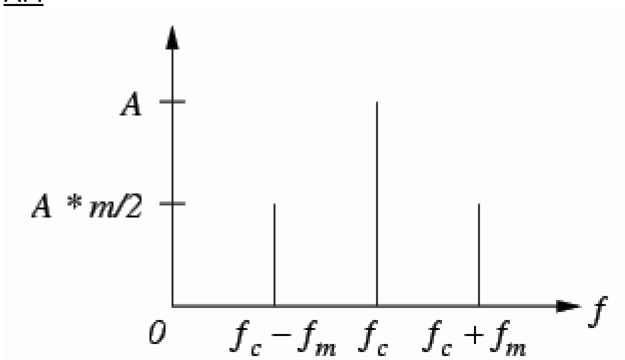
In this project, you will make a simple low-power broadcast-type circuit, using a crystal oscillator integrated circuit and an a collector modulated AM oscillator. You can connect the circuit to the an amplified microphone (no amplified microphone has a to low output voltage to work. at least 100...200mv is needed). You could also add a LF preamp stage of one transistor to allow connecting a microphone directly.

You'll see that you can receive the signal through the air with almost any AM radio receiver. Although the circuits used in radio stations for AM receiving are far more complicated, this nevertheless gives a basic idea of the concept behind a principle transmitter. Plus it is a lot of fun when you actually have it working! Remember that transmitting on 10 or 12 meter band you'll need a valid radioamateur license!

A wide range of different circuits have been used for AM, but one of the simplest circuits uses collector modulation applied via (for example) a transformer, while it is perfectly possible to create good designs using solid-state electronics as I applied here (T1 2N2905).

The transmitter is build as a Colpitts Oscillator with a strong 2N2219(A) transistor. HF-output of the oscillator is 100 to 350 mW, depending on the supply voltage of 9 to 18 Volts. The transmit frequency is stabilized with the 28Mhz crystal. A slight detuning of approx 1kc is possible by using Ct1 trimmer capacitor. The oscillator signal is taken from the collector of T2 by induction and via a low-feedthrough filter and guided to the output via an L-filter circuit cleaning up the signal pretty good. The oscillator is keyed by T1 and the morse key (S). By keying the morse-key T1 is not been used for modulation and is biased, hence lets T2 freely oscillate.

AM



The resulting AM spectrum using sinusoidal carrier and modulating waveforms.

Amplitude Modulation (AM) is a process in which the amplitude of a radio frequency current is made to vary and modify by impressing an audio frequency current on it.
This was the first type of modulation used for communicating signals from one point to another and is still the simplest to understand.
A radio frequency current has a constant amplitude in absence of modulation and this constant amplitude RF carries no information, i.e. no audio intelligence and is of no use to radio telephone (voice communication), but has application in morse code communication.
In its basic form, amplitude modulation produces a signal with power concentrated at the carrier frequency and in two adjacent sidebands. Each sideband is equal in bandwidth to that of the modulating signal and is a mirror image of the other. Thus, most of the power output by an AM transmitter is effectively wasted: half the power is concentrated at the carrier frequency, which carries no useful information (beyond the fact that a signal is present); the remaining power is split between two identical sidebands, only one of which is needed.

CW
CW is the simplest form of modulation. The output of the transmitter is switched on and off, typically to form the characters of the Morse code.
CW transmitters are simple and inexpensive, and the transmitted CW signal doesn't occupy much frequency space (usually less than 500 Hz). However, the CW signals will be difficult to hear on a normal receiver; you'll just hear the faint quieting of the background noise as the CW signals are transmitted. To overcome this problem, shortwave and ham radio receivers include a beat frequency oscillator (BFO) circuit. The BFO circuit produces an internally-generated second carrier that "beats" against the received CW signal, producing a tone that turns on and off in step with the received CW signal. This is how Morse code signals are received on shortwave.

Although this design is primarely designed for AM, it can be used for CW with a slight whistle like sound, but is still usable as CW transmitter by keying S.

RF Oscillator
Is been carried out by T2 (NPN 2N2219). This is the stage where the carrier frequency intended to be used is generated by means of Crystal Oscillator Circuitry or capacitance-inductance based Variable Frequency Oscillator (VFO). The RF oscillator is designed to have frequency stability (Xtal) and power delivered from it is of little importance, although it delivers 250mW@13v , hence can be operated with low voltage power supply with little dissipation of heat.

You could add a switch (very short connections if using an ordinary switch) to select different Xtal's (frequencies). You could also use a more effective diode-based switch I've build here. This hasn't got the problems with longer connections at all.

Filter
RF power amplification is also done here and this stage is coupled to the antenna system through antenna impedance matching circuitry (L1/L2). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands (Ct3, L3, C10). This 3-element L-type narrow bandpass filter circuit for the desired frequency cleans out any remaining harmonic signals very efficiently.

Modulator
Is all done by T1 (PNP 2N2905). Audio information is impressed upon the carrier frequency at this stage. Do to selective components circuits (C3, C4, C7, C5) the voice component frequencies are enhanced, whilest others are suppressed (bandwidth +- 3kc/side) keeping it between HAM-radio specs.

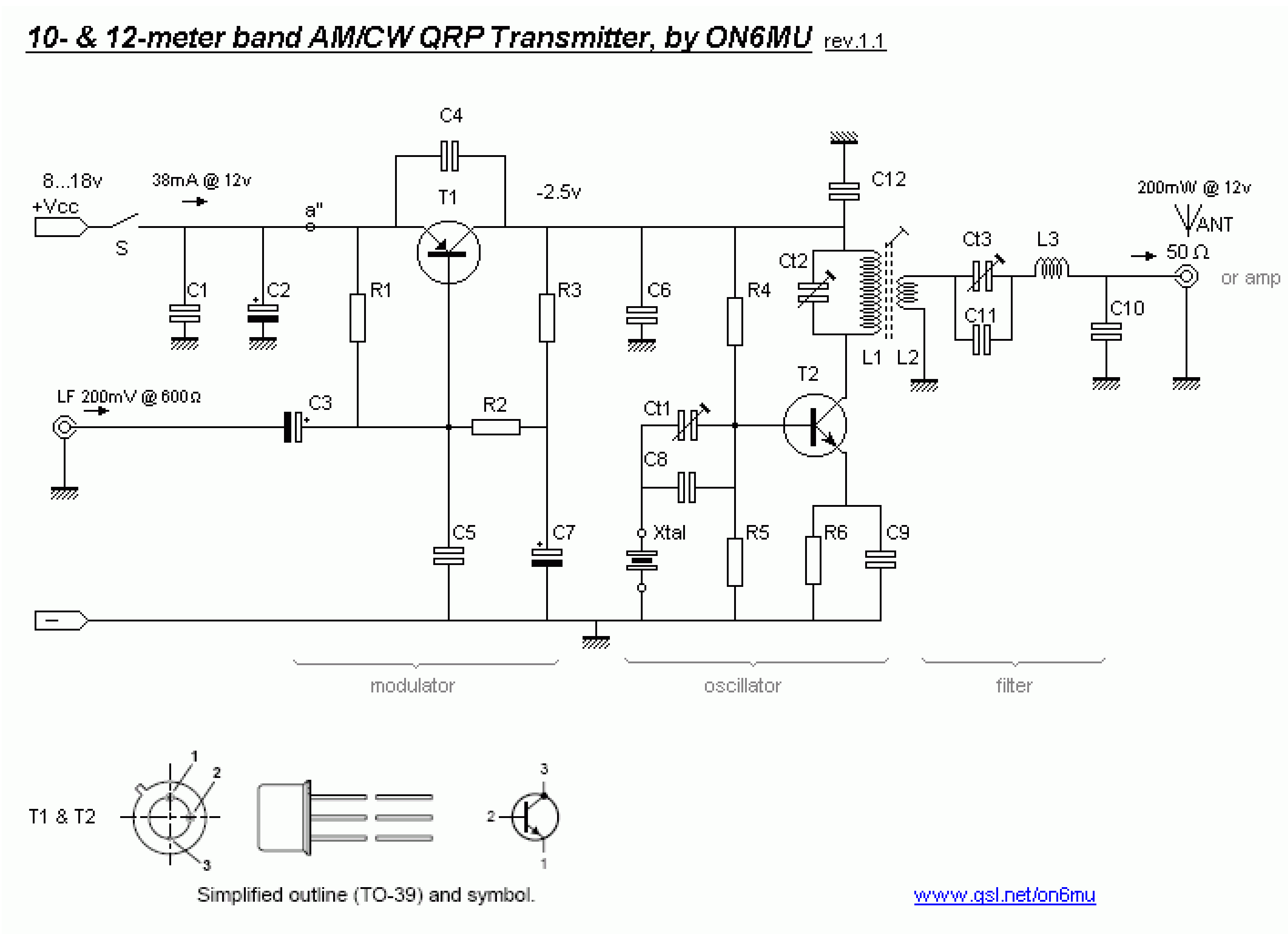
Why over modulation is not desirable?..
Over modulation is not desirable, i.e. modulation should not exceed 100 %, because if modulation exceeds 100 % there is an interval during the audio cycle when the RF carrier is removed completely from the air thus producing distortion in the transmission.

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.

More power
You can connect the output to my power FET based 10-meterband power amplifier wich should cranck up the power to approx. 3 watt. You'll find it here.

Use it with your receiver
If you put a relay, or better a transistor switch to mute your receiver (if equiped) you can easily make a QSO HI. A simple BC338, Bc547, 2N2222 at pin a" with the base biased with a 100k resistor, emmitor at the gnd and the collector fed to your receiver's mute input works fine. Or you can use a 12v relay... Every time you PTT the transistor (or when using a relay, the switch) is "shortened" between the ground, hence muting your receiver (again; if your receiver has mute capabilities).

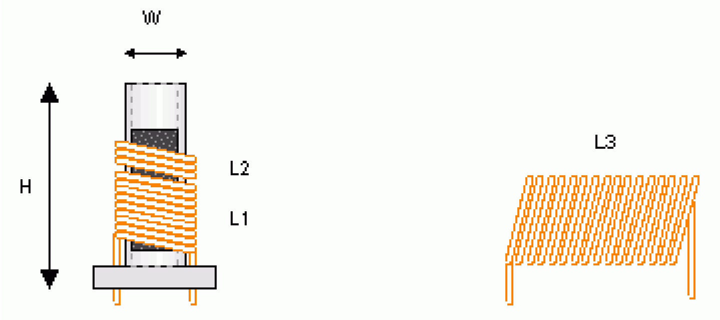
Revision 1.1
C12 needs to be connected as close as possible between the gnd and the L1 cold side (top).



[Parts list 12-meterband AM transmitter]()

- T1 2N2905A
- T2 2N2219A

- C1 100nF
- C6 47nF
- C4 68nF (polyester)
- C2 220uF/25v
- C3 2.2uF/25v
- C5 10nF (polyester)
- C7 2.2uF/25v
- C8 12pF
- C9 220pF
- C10 150pF
- C11 10pF
- C12 470pF
- Ct1= 5...100pF (violet) frequency offset +- 1kc
- Ct2= 5...30pF (brown) set at half position and tune at max power
- Ct3= 5...40pF (white) set at half position and tune at max power
- R1 3k3
- R2 1k8
- R3 1K8
- R4 4k7
- R5 1k8
- R6 82
- L1 = 0.8mm Cul (insulated copper wire), 9 turns close together, 9mm outside diameter (7mm inside)
- L2 = 0.8mm Cul (insulated copper wire), 3 turns close together, on same coil holder as L1 with turnable feritte core
- L3 = 0.6mm Cul (insulated copper wire), 18 turns, 9mm outside diameter (9mm inside)
- Xtal for your desired frequency +- 1kc
- C4, C5, C6 polyester film capacitor



W=7mm, H=25mm, L1=9turns, L2=3turns, L3=18turns 9mm diameter

Specifications

- Peak Frequency range: 24Mc...26Mc
- Output RF power: 100mW@9v - 200mW@12v - 250mW@13.8v - 300mW@16v
- AM modulated +/- 85% (CW if keyed)
- Adjustable output impedance to 50 Ohms
- Band-pass type harmonic L-filter
- Usable voltages: Vcc 5 - 16 volts
- Average current: I 27mA@9v - 38mA@12v - 45mA@16v
- Xtal oscillator,
- Adjustable frequency of 1Kc
- LF input 200mV @ 600 Ohm

Antenna's

It's important to use a correct designed antenna according to band you would like to operate, or at least use a good antenna tuner to match the antenna (protecting your transmitter and proventing harmonics/interference...). Several examples can be found on my website and all across the Web. A dipole is always a good alternative (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your antenna is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is equally important to be able to make DX QSO's.

Remember that transmitting on 12 meter band (or using homemade transmitters) needs a valid radioamateur license!

Another related project:10 meterband AM CW transmitter project

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ON6MU
Home

Four types of Homebrew 12/20/30 Ampere 13,8volt power supplies: RE PSF14A12D, PSF14A20D, PSF14A20 and PSF14A30

RE-PSF14A12D
revision 4

By Guy, de ON6MU

This is an easy to make power supply which has stable, clean and protected output voltage. The overal dimensions can be kept (relative) small by using TO220 darlington BDX-33 transistors. Using 3 BDX-33 darlington transistors is almost 3 times the amount of amps then the power supply delivers, making it real though to brake ;). Although you could use this design to deliver 20 amps (with almost no modifications and with a proper transfo and a huge heat sink with a fan), I did not needed such much power. Second reason was the size of the alu box I happen to have spare HI. There was simply not enough room for the transformer, and surely not enough space to mount a huge heat sink, as the BDX33 transistors can get very hot, and they do not like that so much.
It is obvious, but I would like to mention that you could make this power supply with less BDX-33 transistors if you do not need high power.

Although the 7815 power regulator should kick in on shortcircuit, overload and thermal overheating, I build in a very simple secondary overvoltage protection that's made out of 12 volt relay. The rectified voltage of: 15 volt x SQR2 = 15 x 1.41 = 21.15 volt measured on C1. This is the voltage that could be on the output if one of the transistors should blow. We need a little calculation to get the exact voltage (or higher) to power the 12volt relay which should disconnect the output. In this example we use for diode Zd 9v/5watt -> 21v - 9v = 12 volt. To allow the relay to disconnect the output on lower voltages, use a lower voltage for diode Zd. You could use a different voltage relay too, but diode Zd should be calculated to allow the relay to work just when the output voltage rises over 16 volt + (Zd in the schematic).
Remember that the relay needs to be able to switch 12 amps (or more). If the relay offers multiple switches then please use them. The more the better (also less resistance hence voltage drop when loaded).

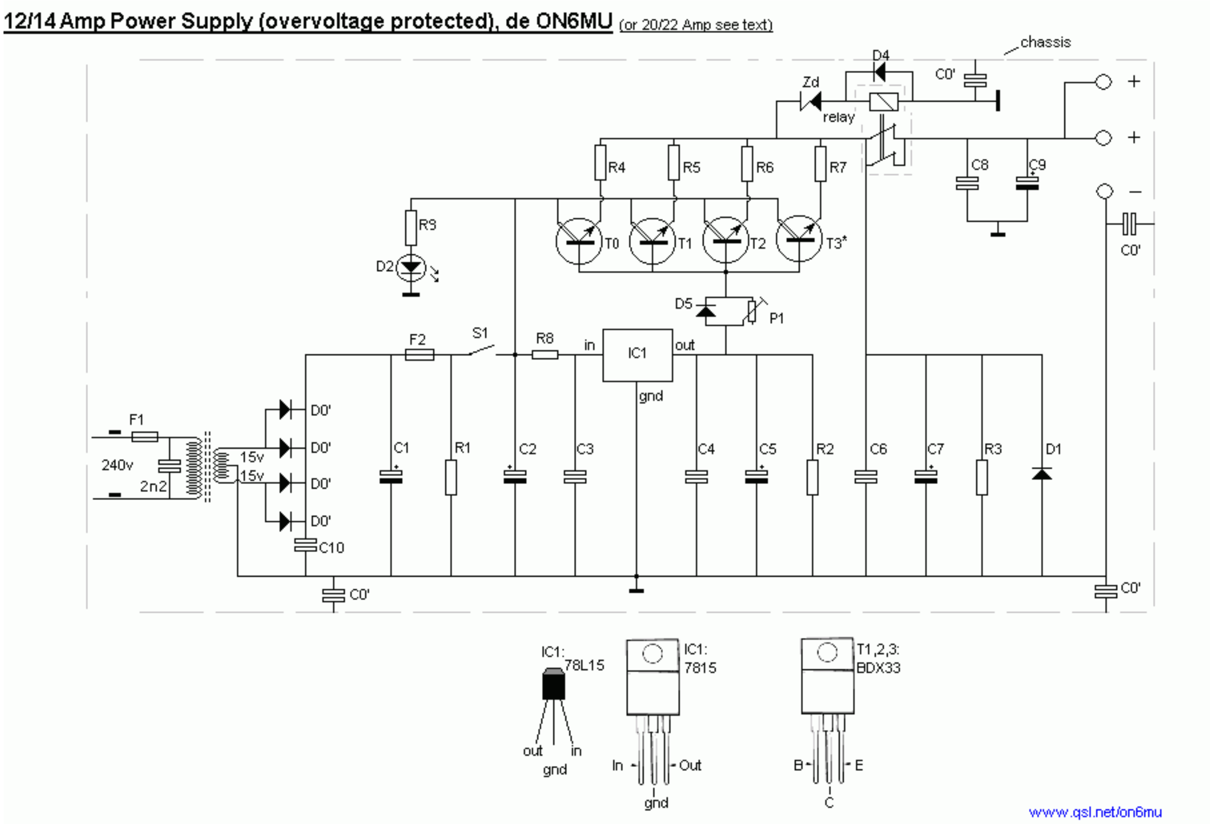
P1 allows you to 'trim' the output voltage exactly to 13.8 volts.

Remember to isolate the transistors from the chassis/radiator! This is very important! Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste. Use thick wires.

Just to be sure to prevent HF entering (or going back to the mains) use a ring core to turn the mains a few times around it (see insides pics).

Revision 3
. Zd was wrongly connected after the relay switch instead of before
. C5 changed to 330uF to improve ripple rejection and stabelisation
. primary side of the transformer added 250v/2n2 decoupling cap
. P1 = 500Ohms or 1k trimmer is sufficient
. reversed diode over IC1 removed

RE-PSF14A12 Power supply Schematic 1



Part list PSF14A12D
12 Amp BDX33-based power supply:

- 2 x 15 volt 6+ amps
- 2 times two MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 2 times 3 1N5401 (1N5408) diodes.
- F1 = 1,5 (2) Amp
- F2 = 15 amp
- R1 2k2 1 Watt
- R2 10k
- R3 1k 0.5 watt
- R4,R5,R6,R7 0.1 ohm 5 watt
- R8 4.7
- R9 6k8
- C1 two times 4700uF/35v
- C2,C5 330uF/35v (revision 2: C5 = 330uF -> improved ripple rejection and stabelisation)
- C0',C3,C4,C6,C10 100nF
- C7 330uF/25v
- C8 47nF
- C9 47uF/25v
- D1 1N5401
- D2 LED
- D4, D5 1N4001
- IC1 78L15
- relay 12 volt 2x5 amp switching
- 3 darlington transistors: T0,T1,T2 = BDX-33 NPN TO-220 transistor
- Zd 8 or 9 volt, 5 watt

- P1 1k trimmer

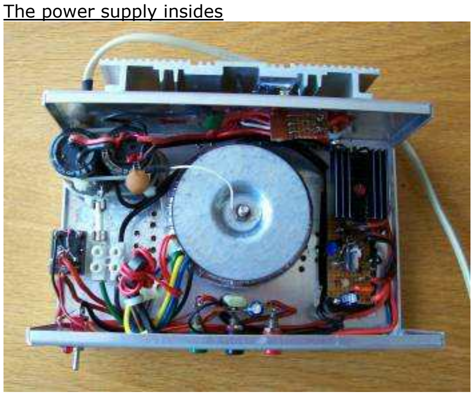
If using a bridge rectifier (like in schematic 2) you do not need 2 x 15 volts 6 amps, but 1 x 15 volt 10+ Amps

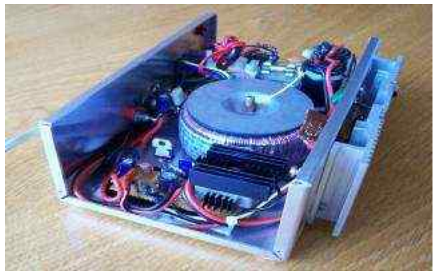
Part List PSF14A20D
20 Amp BDX33-based power supply:

- 2 x 15 volt 12+ amps
- 2 times 3 MR750 (MR7510) diodes (MR750 = 6 Ampere diode) or 2 times 5 1N5401 (1N5408) diodes.
- F1 = 3,18 Amp
- F2 = 25 amp
- R1 2k2 1 Watt
- R2 10k
- R3 1k 0.5 watt
- R4,R5,R6,R7 0.1 ohm 10 watt
- R8 4.7
- R9 6k8
- C1 22000uF/35v
- C2, C5 330uF/35v (revision 2: C5 = 330uF -> improved ripple rejection and stabelisation)
- C0',C3,C4,C6,C10 100nF
- C7 330uF/25v
- C8 47nF
- C9 47uF/25v
- D1 1N5401
- D2 LED
- D4, D5 1N4001
- IC1 7815
- relay 12 volt 10 amp switching
- Four darlington transistors: T0,T1,T2,T3 = BDX-33 NPN TO-220 transistor
- Zd 8 or 9 volt, 5 watt
- P1 2k trimmer

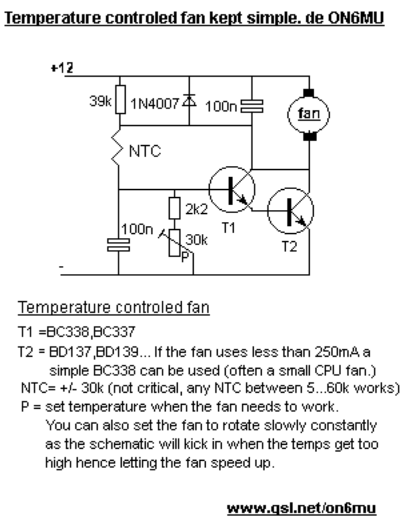
If using a bridge rectifier (like in schematic 2) you do not need 2 x 15 volts 12 amps, but 1 x 15 volt 20 Amps

The power supply insides



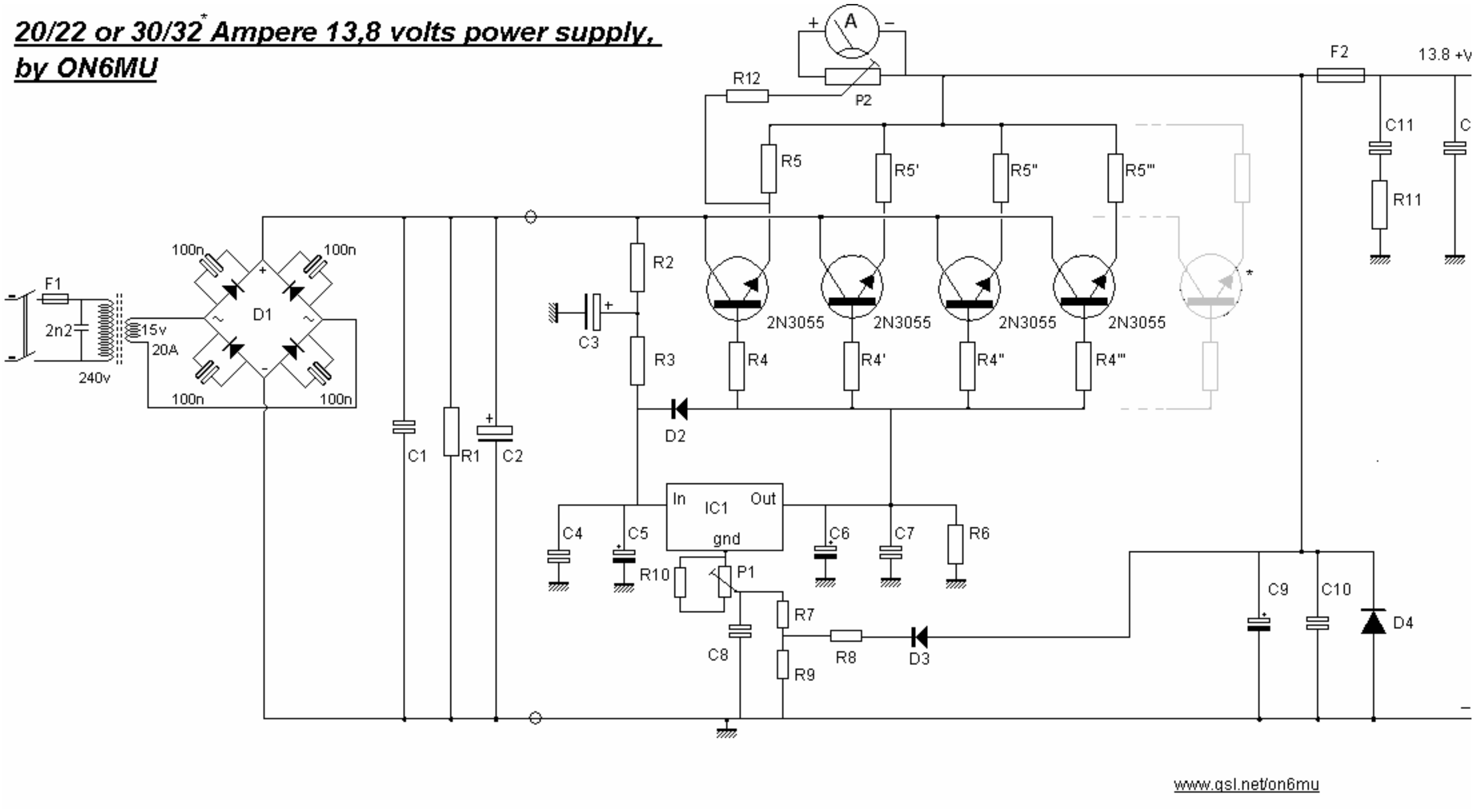


A simple temperature controled fan:



20/22 Ampere or 30/32 Ampere 13.8 volts power supply
RE-PSF14A20 or PSF14A30
de ON6MU

RE-PSF14A20
Power Supply Schematic 2 (new design) revision 2014



Remember to isolate the 2N3055 transistors from the chassis/radiator! This is very important! Use a radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.

PSF14A20 Specs

- Heavy duty power supply 13.8 volt, 20 or 30 amps continue
- low ripple
- short-circuit protection
- HF-immunity
- Voltage can be set between 12,3 and +/- 15 volts
- only 0.35v drop at full load
- parts widely available and calculated way over the maximum load

PSF14A20 Parts (30 amp version PSF14A30 in blue)

- transformer capable of delivering 20 amps @ 15volt (30 amps)
- 4 x 2N3055 (6 x 2n3055) (you can also use the 2N3773 transistor)
  Use a large radiator (heat sink) of appropriate size and surface area; insulating and heat-conducting spacer or at least a thin mica; hot adhesive and thermal paste.
- IC 1: 7812 (small heatsink)
- D1: MB2504 is used as it is a 25 ampere rectifier bridge and should also be very good cooled.
  Or you could use 3 times four BYW29 8 amp diodes (TO220 pinning, cooling).
- D2 & D3: 1N4001 or simular
- D4: 1N5401 or simular (1N5400...1N5408)
- C1: 47nF
- C2: 22000uF (+ 10000uF) 35volts
- C3: 100uF/35volt

- C4: 100nF
- C5: 4.7uF/35volt
- C6: 4.7uF/35volt
- C7: 100nF
- C8: 220nF
- C9: 220uF/25volt
- C10: 47nF
- C11, C12: 100nF
- R1: 2k2 / 1W
- R2: 10 1/2W (2,2 1/2W)
- R3: 6,8 1/2W (2,2 1/2W)
- R4': 1 Ohm 1/2W
- R5': 0.1 Ohm/5W
- R6: 2k2
- R7: 10
- R8: 2k2
- R9: 22
- R10: 1k5
- R11: 10
- R12: 220
- P1: 1k
- P2: 2k2 trimmer (to calibrate the meter that will be used to measure the amps)
- F1: 2A (3.18A)
- F2: 22A (35A)

P1 allows you to 'trim' the output voltage exactly to 13.8 volts.
Just to be sure to prevent HF entering through the mains use a ring core and turn the mains a few times around it (see insides pics).
Be sure to use thick braid wires!!! They need to handle 20 (30) amps continues!

Total revision changes:

. highly improved voltage stabilisation
. output voltage feedback circuit stabilisation
. BDX-33 removed
. Cap after 7815 changed from 1uF to 4.7uF
. Resistors before the input of the 7815 changed
. reverse diode (between collector and emittor of 2n3055) removed
. voltage can be set exactly to 13.8v (P1)
. minor HF-immunity changes
. reversed diode over IC1 removed

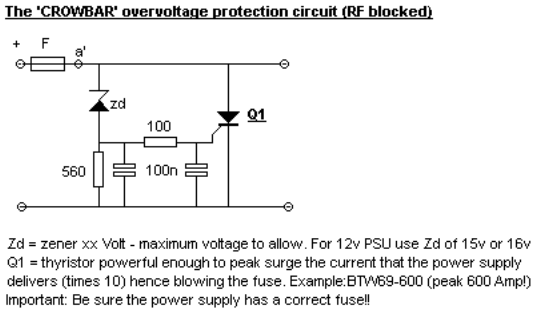
Revision 2016:

. R10 changed 1k5, and P1 to 1k (thanks Goran 9A6C)
Goran reported that he could not reach 13.8 volts using a 500 Ohm potentiometer(P1) parallel with the 1k resistor(R10).
Replacing P1 & R10 with fixed resistor of 680 Ohm would give approx. 13.6 volts.

. Revision 2017: added ampere meter without using the meter in series (P2 trimmer to calibrate the meter that will be used to measure the amps)

Overvoltage protection:

A crowbar circuit is an electrical circuit used to prevent an overvoltage condition of a power supply unit from damaging the circuits attached to the power supply. It operates by putting a short circuit or low resistance path across the voltage output (Vo), much as if one were to drop a crowbar across the output terminals of the power supply. Crowbar circuits are frequently implemented using a thyristor, TRIAC, trisil or thyratron as the shorting device. Once triggered, they depend on the current-limiting circuitry of the power supply or, if that fails, the blowing of the line fuse or tripping the circuit breaker.



Pictures of people who made the PS

This is how Dan, YD1BWB made it:

click on the images to enlarge

Thanks Dan!

Links of interest:

.**ON6MU Homebrew projects**
.Radioamateur related projects
.**ON6MU 78h05 powersupply**
.Versatile 7805 based 5Amp powersupply

Home
www.qsl.net/on6mu

ON6MU

13,8v/5Amp 78H05 based power supply for portable use: RE-PSF14A5

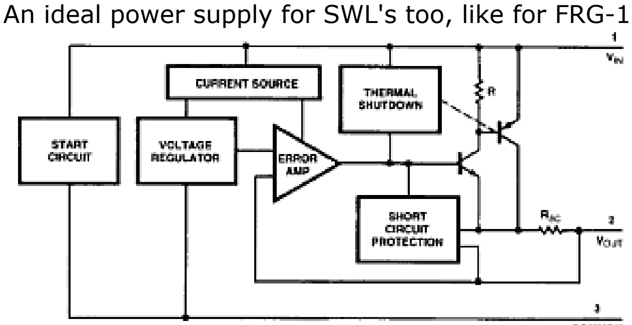
FT-817

By Guy, de ON6MU

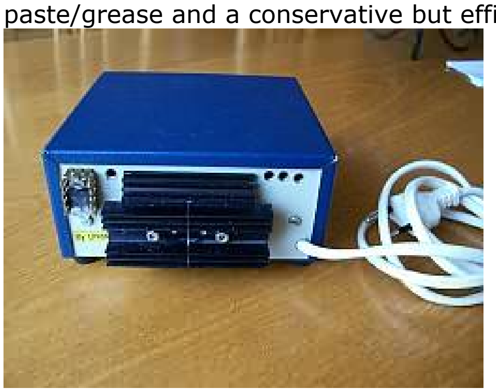
I wanted a compact but powerful and versatile power supply to take along when I go on vacation, camping etc.
I use this power supply for a Yaesu FT-817ND and similar (QRP) transceivers. This transceiver uses 2 amps at full 5 watt TX and so the power supply has a large enough margin to let the build-in battery cells to charge and let your FT-817 work at full power and still have power to spare. Still, this power supply is compact enough to be used for portable use and the FT-817 fits perfectly on it HI. Ok, the power supply could be made smaller, but I needed 5 amps to use with my power hungry TM-255 @ 5 TX watt power.

The 78H05 can easily manage 5 amps at constant full load, has thermal overload protection, short-circuit protection and safe area protection! If the safe operating area exceeds, the device shuts down rather then failing and damaging your expensive transceiver/equipment!

If you do not need 5 amps you can always use lesser diode bridge and transfo amps which allows you to reduce the size of the power supply. The FT817 and simular QRP transceivers often don't need more then 2 to 3 amps anyway.
An ideal power supply for SWL's too, like for FRG-100 and so many others.



Remember to isolate the 78H05 and the 7805 from the chassis! This is very important! Also use thermal cooling paste/grease and a conservative but efficient heat sink.



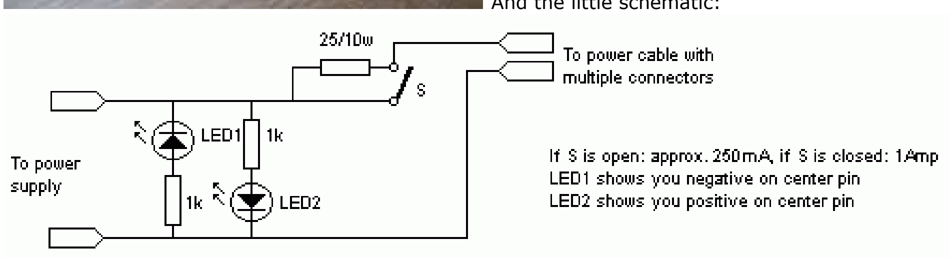
The zenerdiode is a 5watt (1,3 watt should be sufficient too) 8,2 volt type and the extra diode in series gives you an extra 0,6 volt which gives you exactly 13,8 volts (5volt + 8,2volt + 0,6volt). Most transceivers can work with lower voltages, so if you want you can leave out the diode and so giving you an output voltage of 13,2 volt.
S1 is used to switch and monitor between the two voltage regulaters output. Calibrate the meter by using the 4k7 pot.

For personal use I included a little 1 amp circuit along with it to be used for other equipment (or batteries etc.) when I'm at /A or /P. Switching S2 and S3 can obtain you 4 different voltages depending on the two zenerdiodes zd1 and zd2. This saved me carry space because I do not need to take along other power supplies for my little radio, portables etc. For this reason I made a charger interface (or you can choose to build it in) and a cable with 6 different types of connectors (also a 9 volt clip). You can change zd1 & zd2 to whatever voltages you might need on your /A adventure. The connector is been fed through a 25 Ohm 10 watt resistor which can be switched on and off to be used as a simple current reducer for battery charging. I mounted the resistor agains the metal chassis of the switch which helps to cool it down a little if using 12 (or more) volts via the 78M05 (1AMP).

The second way (instead of switching between fixed voltages) is a schematic that uses the 7805 to continues regulate the output voltage bewteen 5 to 14 volts. You may choose whatever principle you have the best use for in your power supply.

<u>The multi-functional power connector</u>

And the little schematic:

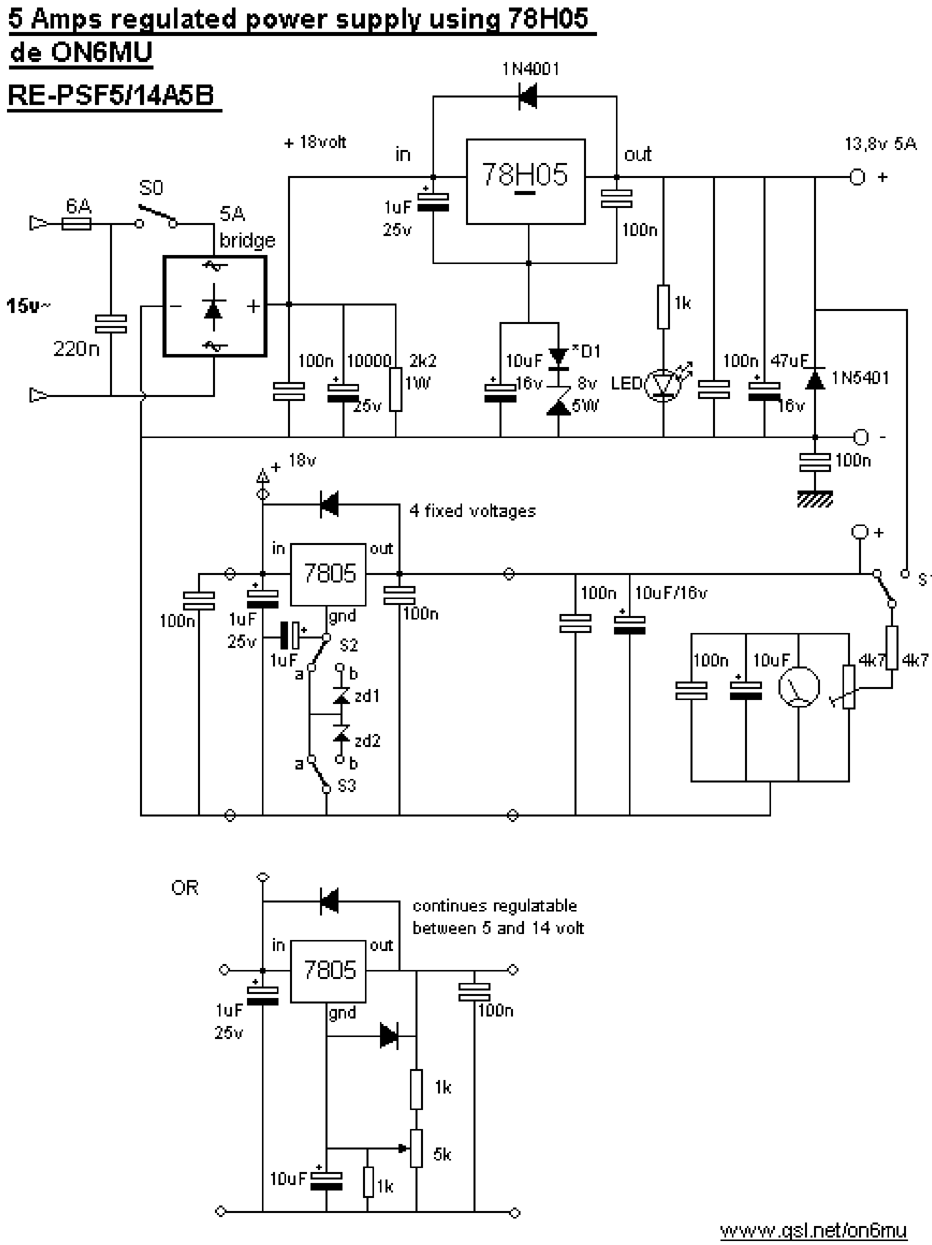


As some devices uses reverse polarity (negative on the center pin) I placed two LED's to show you which polarity is used.

Zd1=2,4v/Zd2=4,3v

S2	S3	V
a	a	5
b	a	7,4
a	b	9,3v
b	b	12

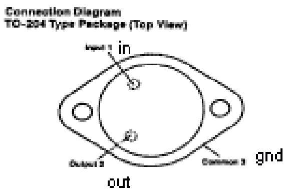
<u>RE-PSF14A5 Schematic</u>



The power supply insides

Dimensions:

Alu box: 132x55x128



78H05

Technical specs:
Description = Fixed Positive Voltage Regulator
Output Voltage Nominal (V) = 5.0
Load Current Max. (A) = 5.0 - 6.0 peak
Load regulation = 0.2% V-Out
Tolerance (%) = 1.0
Drop-Out Volt Max. = 2.5
P(D) Max.(W) Power Dissipation = 50.0
Supply Voltage Maximum (V) = 30.0
Temperature = -55C° to 150C°
Package = TO-3
Pins = 3
Military = N

More of my projects:
12-20amps power supply

The power supply in my quick-take-along-emergency-ft817-carry-case (what a name!)

[FT817](#)

[Home](#)
www.qsl.net/on6mu

ON6MU

ON6MU

Long Wave, Medium Wave and Shortwave Radio Experiments

1) Attempt to make a general coverage receiver (RE-RX1LM/HF)

LW, MW and SW bands


rev1.1

About RX1LM/HF

This is a compact three transistor regenerative general coverage receiver with fixed feedback. It's based on the principle of the ZN414 only it can handle higher coverage. The sensitivity and selectivity is relative good (especially on the LF and MW bands) as can be expected with this "simple" design. The reception on the broadcast bands, LW(longwave) & MW(mediumwave) needs no external antenna! Just a ferrite rod which can be recovered from an old portable MW/LW radio which tuned from approximately 540 - 1600kHz on MW and 140kHz-240kHz for LW. If you have an old MW/LW (portable) radio you'll wont need to make your own coils for those bands if you use those.

An AM radio receiver is fundamentally a very simple device. In its simplest form, a resonant circuit builds up a signal if there is one in space at the frequency to which it is tuned. A crystal (galena) then rectifies the signal, which reproduces the modulation. All the energy comes from the received electromagnetic wave. A good receiver must combine sensitivity and selectivity. Sensitivity is obtained by amplification in several stages, while selectivity is obtained by a narrow bandwidth of the amplifiers. There is a severe problem if the receiver must tune over a reasonable interval, such as the medium-wave broadcast band from 550 kHz to 1.65 MHz. The filters of the several stages of amplification cannot track well enough as their frequency is varied if the bandwidth is narrow, so one must choose between sensitivity and selectivity in such a tuned-RF receiver. There are other problems as well, such as the variation in selectivity as the circuits are tuned over a wide range.

It doesn't need a external power supply as the total current is very low (total 12mA) and can be fed with just 3 (chargeable) batteries. Transistor T3 has a dual purpose; it performs demodulation of the RF carrier whilst at the same time, amplifying the audio signal. Audio level varies on the strength of the received station but I had typically 10-40 mV. This will directly drive the TDA7052 and drives a 8 Ohm speaker up to 0.5 watt @ 3.6volts.
T1 and T2 form a compund transistor pair featuring high gain and very high input impedance. This is necessary so as not to unduly load the tank circuit. T1 operates in emitter follower, T2 common emitter, self stabilizing bias is via the 56k resistor, the 150pF capacitor and the tuning coil.

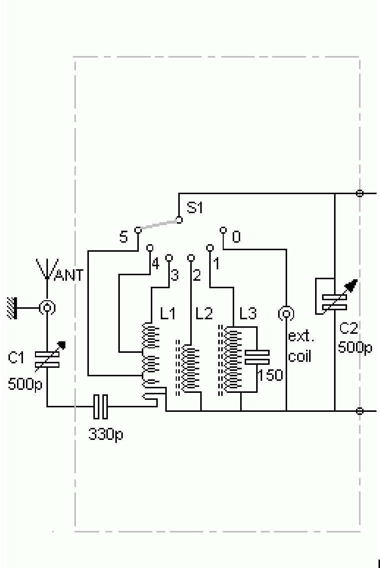
P1 set the audio volume.

All connections should be short, a veroboard or tagstrip layout are suitable. The tuning capacitor has fixed and moving plates where the moving plates should be connected to the "cold" end of the tank circuit, this is the base of T1, and the fixed plates to the "hot end" of the coil, the juction of 56k/150p/100n. If connections on the capacitor are reversed, then moving your hand near the capacitor will cause unwanted stability and oscillation.

Switch between the coils (being the frequency bands) with S1. The tapping points on the coil allow the set to be tuned to different frequencies by adjusting the position of tap-switch S1.

You can also replace the "RF amplifier/demodulator unit" with a ZN414/MK484 as shown on lower on this page but without the BC109 LF amp, or you can leave it and change the 10k pot with a 10k trim potentiometer to be able to adjust the volume that is fed to the TD7052. One thing though...The ZN414 does not handle LW very well (bad is more appropiate).

Shortwave?



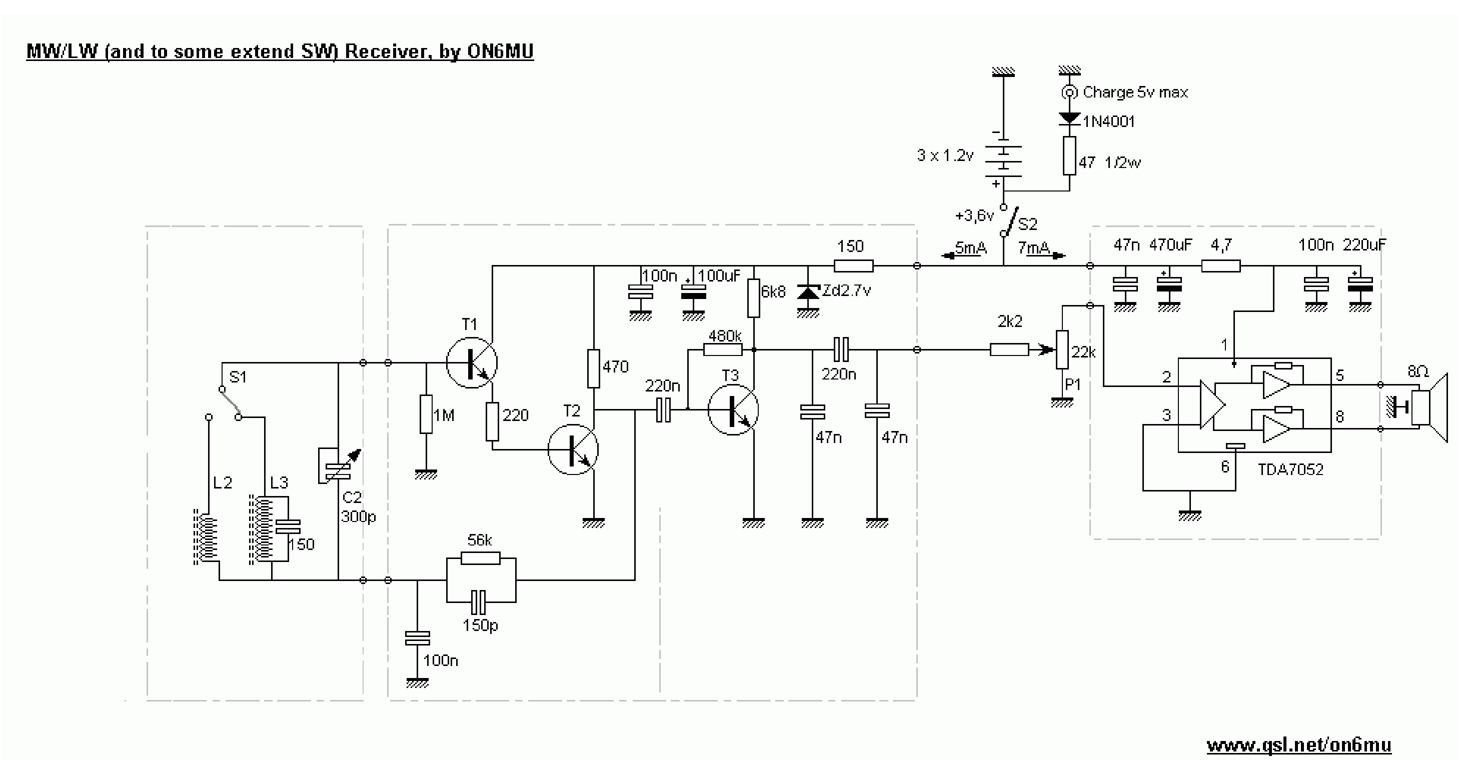
I have experimented with this radio and it could reach up to 24MHz. However, sensitivity and selectivity suffers as frequency goes up. It also needs an external antenna when wondering about on those shortwave frequencies. I would also recommend to use a variable C1 in series with the antenna connector to avoid the receiver being saturated at higher frequencies (shortwave) when using a longwire or any other "large" antenna that isn't resonant. Using a real antenna tuner would be even better... The sensitivity is not as good as on MW and LW though, nor is the selectivity. I've put a RCA/Cinch-connector (or better, a BNC-connector) at the band switch to allow experiments with different types of coils for different frequency ranges.

<u>Frequency coverage RX1LM/HF</u>
LW : 140 - 240 KHz (good)
MW: 520 -1600 KHz (good up to 3Mc)

Experimental:
SW1: 2500 - 6000 KHz (moderate)
SW2: 5 Mhz - 14 MHz (moderate)
SW3: 12 MHz - 24 MHz (low)

<u>Mode</u>: AM

Schematic



Tuning unit RF amplifier/demodulator unit LF output amplifier

Details - Coils

L2: 4 mH, 550 turns on a 9/10mm ferrite rod OR MW 'loopstick' antenna scrapped from an old transistor radio
L3: 310 uH, 65 turns on a 9/10mm ferrite rod OR LW 'loopstick' antenna also 'recycled' from an old transistor radio (both L2 and L3 are on the same ferrite core)

The loopstick antenna coil is best wound on a bit of cardboard or plastic tube around the ferrite rod. The coil can then be slid along the rod to adjust the tuning range. Use this to set the low-frequency end of the band. If you need to set the upper end of the band then place a capacitor across the tuning cap and re-adjust the low end of the band again (in schematic L3 150pF). Experiment.

S1: 2 way switch (MW/LW band selection)

For SW experiments:
**L1: total of 37 turns of 0.65mm on a 18mm diameter plastic tube of 30 mm height:*
taps at 24 turns, 8 turns, 3 turns, 2 turns

S1: 6 position rotary switch

Transistors
T1, T2, T3 = BC547 NPN

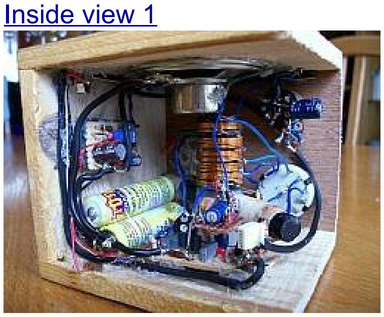
Specs

- Frequency range: 140 kHz - 3000 KHz (maximum limit 24 MHz). LW & MW bands needs no external antenna.
- U = 3...12 volts *Battery or external power operated
- 3 x 1.2 volt chargeable batteries
- I = 12mA @ 3.6volts
- Output LF power: 500mW @ 3.6volts, 1Watt @ 12 volts
- PL259 connector for external antenna (used for the shortwave bands)

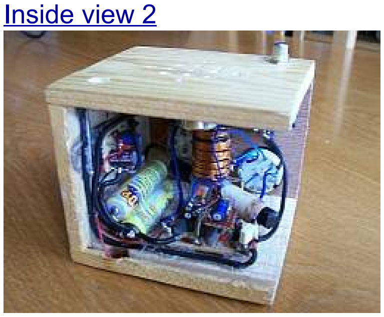
The receiver sensitivity and selectivity is more then fair on LW and MW bands up to 3Mc. However, the higher you go in frequency (> 3 Mhz) the less sensitivity and selectivity the radio will have. This could be improved by using a selective pre-amp between the shortwave bands (S1: position 3,4,5).

top view

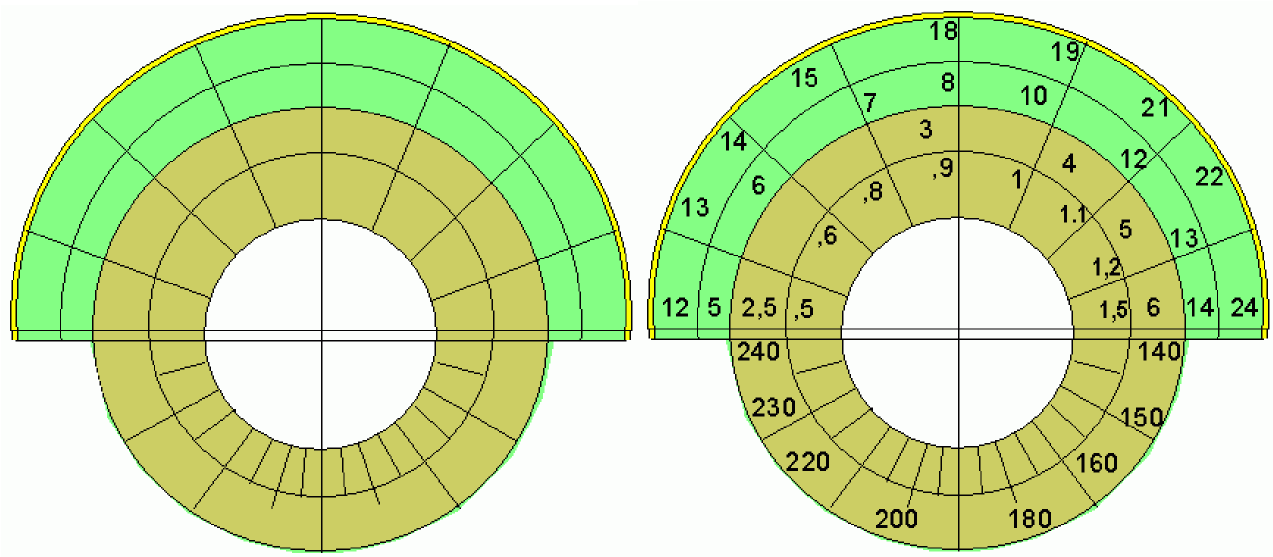
Inside view 1



Inside view 2



Dial scale (with the SW experimental scales included)

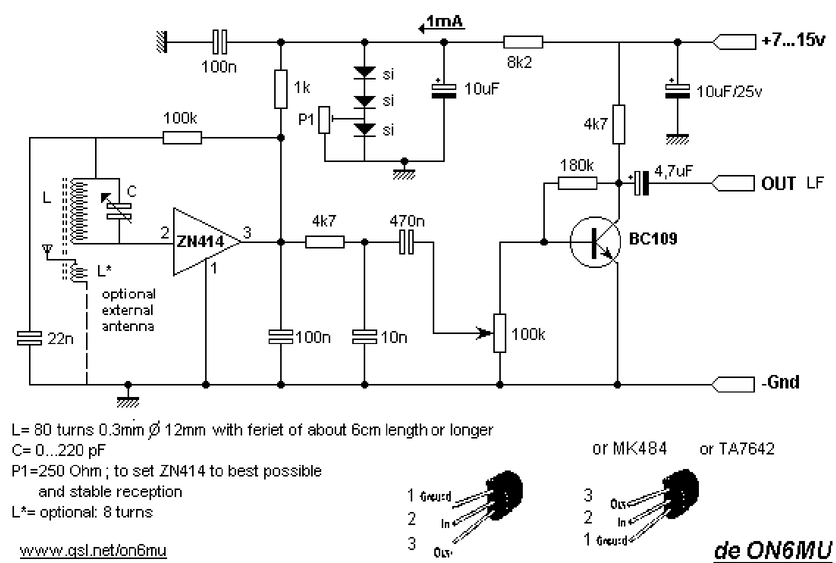


More of my projects: [50 Mhz converter/receiver]

2) RE-RX2MW: MW receiver based upon a ZN414

(retired, but can be replaced by a much better MK484 or TA7642)

Fig1. Electronic diagram MW-receiver **Revision 3.0**



The MK484 easlily goes up to 3Mc and even somewhat beyond. Experiment with the RX1LM/HF coils on the top of this page!

AM radio is broadcast on several frequency bands:

Long wave is 153–279 kHz; it is not available far into the Western Hemisphere, and European 9 kHz channel spacing is generally used (historically frequencies as high as 413 kHz were used but currently there are no terrestrial LW broadcasters above 279 kHz).
Medium wave is 520–1,610 kHz. In the Americas (ITU region 2) 10 kHz spacing is used; elsewhere it is 9 kHz. ITU region 2 also authorizes the Extended AM broadcast band between 1610 and 1710 kHz.
Short wave is 2.3–26.1MHz, divided into 15 broadcast bands. Shortwave broadcasts generally use a narrow 5 kHz channel spacing.
The allocation of these bands is governed by the ITU's Radio Regulations and, on the national level, by each country's telecommunications administration (the FCC in the U.S., for example) subject to international agreements.

Long wave is used for radio broadcasting in Europe, Africa, Oceania and parts of Asia (ITU regions 1 and 3). In the United States and Canada, Bermuda and U.S. territories this band is mainly reserved for aeronautics, though a small section of the band could theoretically be used for microbroadcasting under the United States Part 15 rules. Due to the propagation characteristics of long wave signals, the frequencies are used most effectively in latitudes north of 50°.

Medium wave is by far the most heavily used band for commercial broadcasting. This is the "AM radio" that most people are familiar with.

Short wave is used by audio services intended to be heard at great distances from the transmitting station. The long range of short wave broadcasts comes at the expense of lower audio fidelity. The mode of propagation for short wave is different (see high frequency). AM is used mostly by broadcast services — other shortwave users may use

a modified version of AM such as SSB or an AM-compatible version of SSB such as SSB with carrier reinserted. In many parts of the world short wave radio also carries audible, encoded messages of unknown purpose from numbers stations.

Frequencies between the broadcast bands are used for other forms of radio communication, such as baby monitors, walkie talkies, cordless telephones, radio control, "ham" radio, etc.

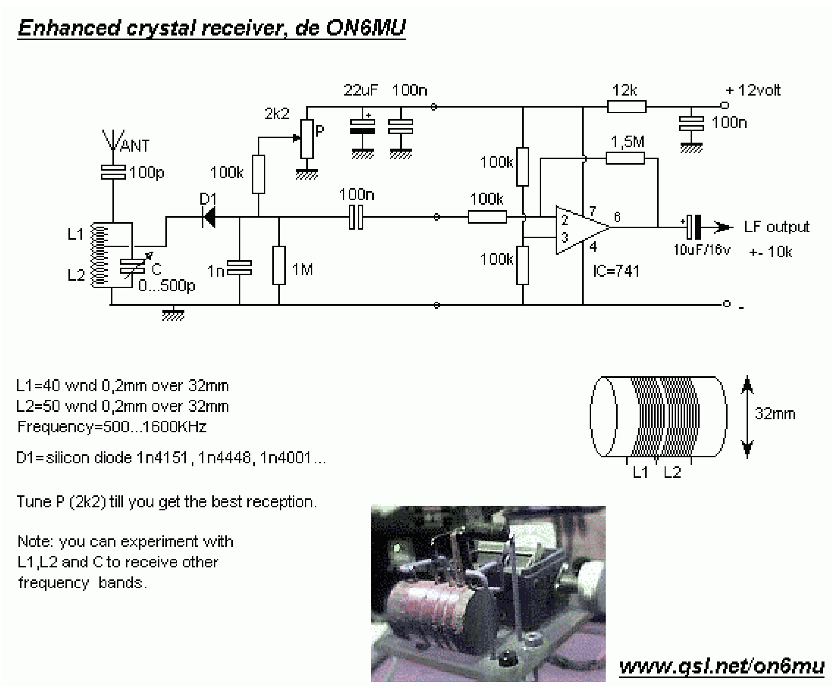
AM radio signals can be severely disrupted in large urban centres by concrete bridges with metal reinforcements, other Faraday cage structures, tall buildings and sources of radio frequency interference (RFI) and electrical noise, such as electrical motors, fluorescent lights, traffic signals, or lightning. As a result, AM radio in many countries has lost its dominance as a music broadcasting service, and in many cities is now relegated to news, sports, religious and talk radio stations although some musical genres — particularly country, oldies, nostalgia and ethnic/world music — survive on AM, especially in areas where FM frequencies are in short supply or in thinly populated or mountainous areas where FM coverage is poor.

Also more of my homebrew projects:

ON6MU Homebrew projects
Radioamateur related projects

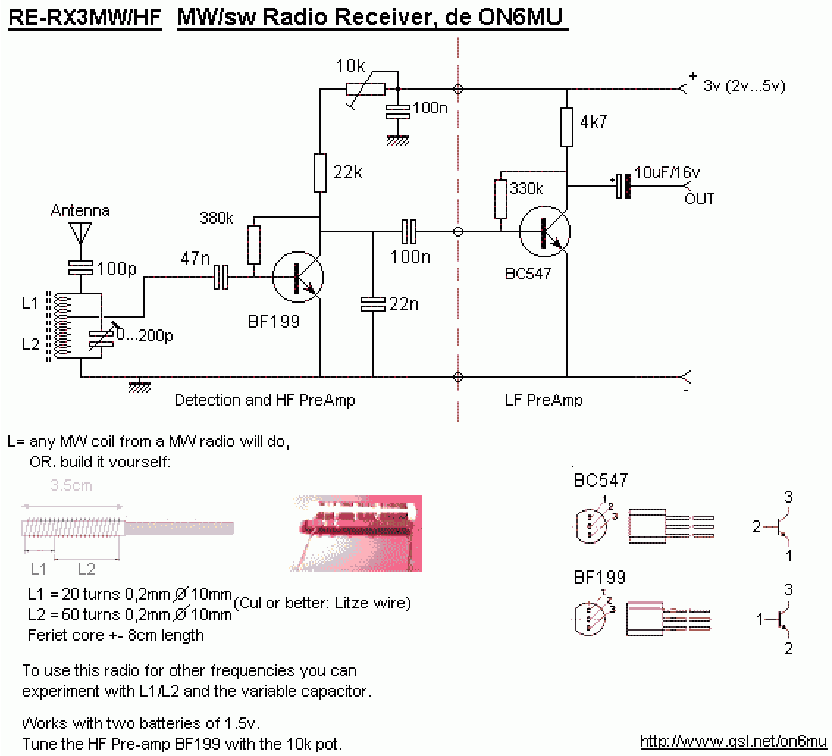
ON6MU Ham mods
Modifications of transceivers

3) RE-RX1MW: Enhanced Crystal MW Receiver



3) RE-RX3MW/HF: Enhanced Crystal MW/SW Receiver

(using one transistor for HF amplification and detection)



73"

ON6MU

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Radio kits velleman. Radio converter kits. Kenwood, Yaesu receivers. Electronics schematics of radios. Building kit of a home made crystal radio with transistor components. Receiver commercial receiving antenna. shortwave listening with receivers. Build your own shortwave receiver. Performance not as a Kenwood or Yaesy receiver but so much more fun to receive world wide signals. Not using integrated circuits. Circuits integrated components of electronical contents. Antenna longwire for shortwave reception.

ON6MU

50 MHz converter

RE-RXC50/10

Receive singals from the "Magic Band" on your shortwave receiver!

About the 6-meterband converter RXC50/10:

This is a very sensitive 50Mc converter allowing you to receive the entire "Magic Band" (50Mc...52Mc) on your general coverage receiver (28Mc...30Mc). It receives all types of modulated transmissions. It all depends on the receiver used. I've tested this project on a allmode Yaesu FRG-100 receiver. Within certain limits you can change the output frequency to suit your needs. The converter is very stable, low nois, sensitive and low on power consumption and can be compared to many commercial 50Mc receivers.
The heart of the converter has been built around Philips SA602 (NE602 or NE612), a twice balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 15mA. Therefore also uncomplicated usable applications fed with battery.

The SA602A is a low-power VHF monolithic double-balanced mixer with input amplifier, on-board oscillator, and voltage regulator. It is intended for high performance, low power communication systems. The guaranteed parameters of the SA602A make this device particularly well suited for cellular radio applications. The mixer is a “Gilbert cell” multiplier configuration which typically provides 18dB of gain at 45MHz. The oscillator will operate to 200MHz. It can be configured as a crystal oscillator, a tuned tank oscillator, or a buffer
for an external LO. For higher frequencies the LO input may be externally driven. The noise figure at 45MHz is typically less than 5dB. The gain, intercept performance, low-power and noise characteristics make the SA602A a superior choice for high-performance battery operated equipment. It is available in an 8-lead dual in-line plastic package and an 8-lead SO (surface-mount miniature package).

50 MHz converter technical specifications

- Frequency range from 50.000 MHz to 52.000 MHz
- 50 Mc in = out 28 Mc (or 26Mc when using 24MHz LO Xtal)
- Power supply = 9...18v max
- Total power consumption = 15mA (LED included)
- Power consumption IC1 = 2,5 mA

- Sensitivity = 0.22uV at 12dB SINAD
- Mixer noise figure = 4,6dB
- Input impedance = 50 Ohm
- Output impedance = 50...600 Ohm
- Local oscillator 22MHz
- Frequency stability = +/- 5Hz
- Operating ambient temperature range = -40 to +85°C

RXC50/10 SCHEMATIC

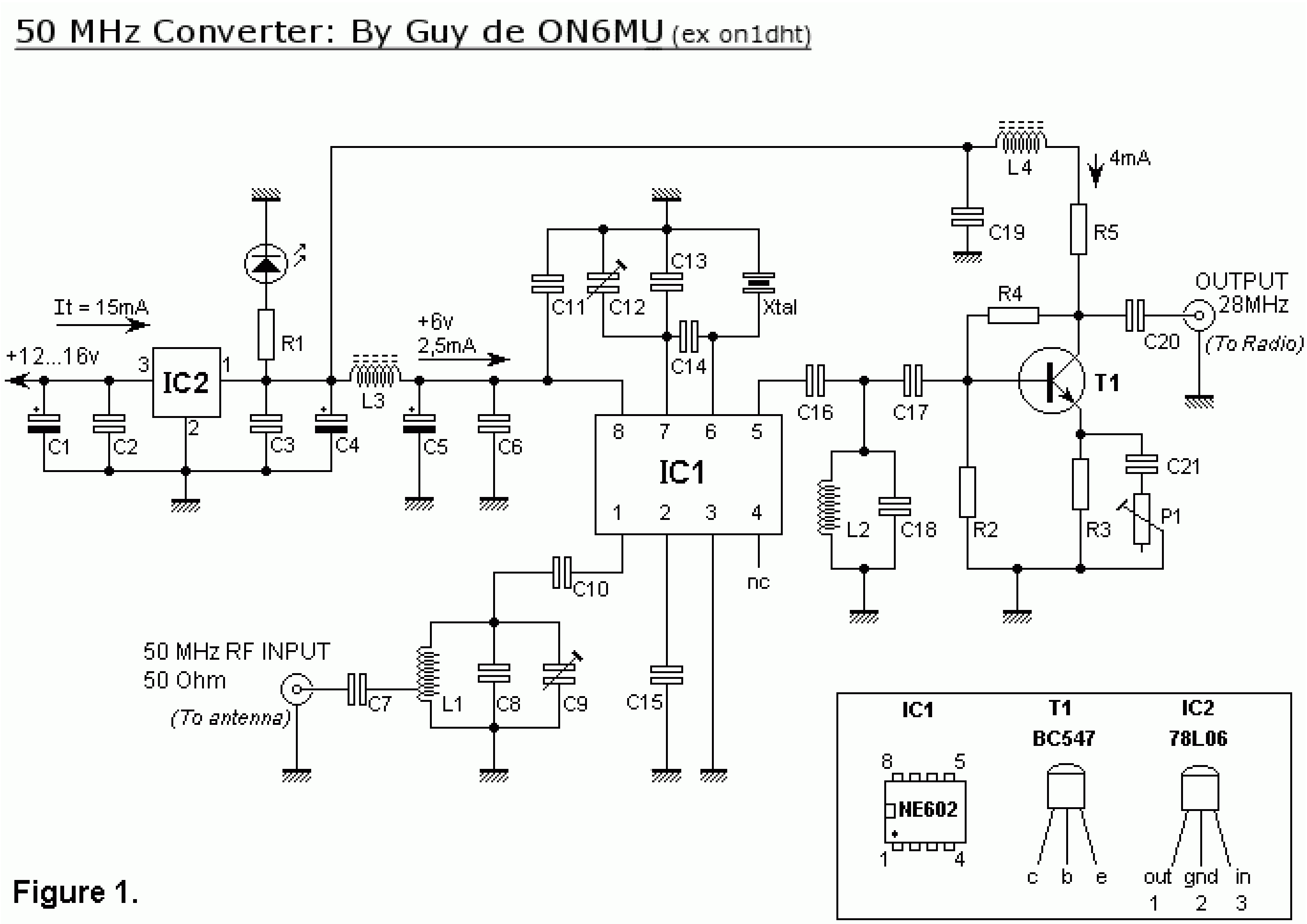


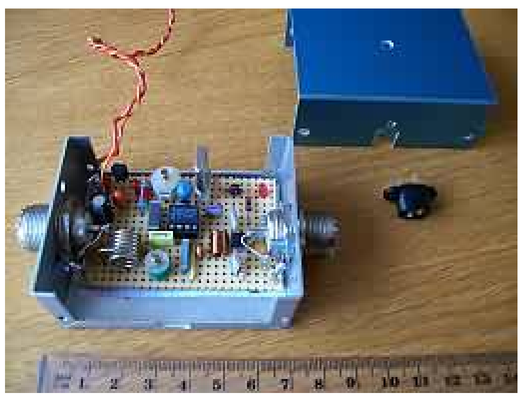
Figure 1.

PARTS

IC1 = NE602, NE612, SA602A, SA612A
IC2 = 78L06
T1 = BC547 or BC338
C1 = 10uF/25v
C2 = 100nF
C3 = 100nF
C4 = 10uF/25v
C5 = 47uF/16v (tantaal)
C6 = 47nF (polyester)
C7 = 47pF
C8 = 22pF
C9 = 0...22pF (green)
C10 = 2n2
C11= 4.7nF
C12 = 0...40pF (white)
C13 = 47pF (poly)

C14 = 39pF (poly)
C15 = 47nF (polyester)
C16 = 330pF
C17 = 330pF
C18 = 100pF*
C19 = 4.7nF
C20 = 470pF
C21 = 470pF
P1 = 100 Ohm
R1 = 1k
R2 = 2k2
R3 = 100 Ohm
R4 = 5k6
R5 = 1k
P1 = 100 Ohm

Coil specifications:
L1 = 7 wnd 1mm silver 9mm coildiameter (drill 7), tap on 1,5 wnd from the cold end.
L2 = 11 wnd 0,6mm email 5mm coildiameter (drill 4)
L3, L4 = shokes (RFC) 10uH +/- or use a ferite bead

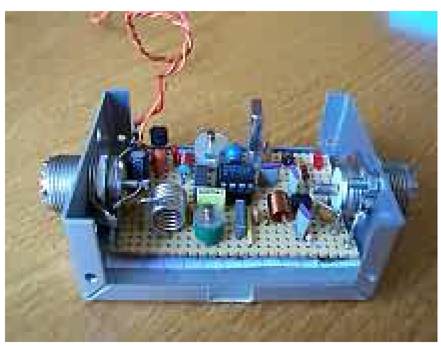


The converter explained

The heart of the converter has been built around Philips SA602 (NE602), a double balanced mixer oscillator. This IC finds his applications in layer capacity communication systems, cellular radio applications, RF data left, VHF-transceivers, broadband LAN's ed. IC in a ordinary 8-pin dual-in-line can be bought implementation (DIP) or 8-pin SO (surface-mount miniature package) implementation. Both implementation has a low cost. SA/NE602 a very low usage of only 2,4mA has! The total usage of the converter amounts to only 15mA. Therefore also uncomplicated usable applications fed with battery.
The mixer is Gilbert cell tip quadrant configuration which 18dB can provide conversion gain. The built in Local oscillator work to maximum 200MHz tank oscillator coordinated with a high Q or crystal oscillator. The highest frequency which we can bring to the input of this IC amounts to 500MHz.
In this project we apply a crystal retrieve oscillator. Frequency stability is excellent and depends mostly of the surroundings temperature crystal then the IC itself. As it happens, a very ingenious and efficiently temperature compensating bias is built in. Important to know is that the oscillator already has an internal bias and therefore don't need extra dc-bias. Only at very high frequencies a raised direct current can be necessary. This one remedies by placing between the mass and resistor at pin 7 of a value of of 22k.
The NE602 LO works up to 200MHz and the input up to 500MHz, therefore a huge 'reserve' is available since we use a much lower LO input frequency. We want to convert, as it happens, 50MHz to 28MHz. This means therefore that we must mix with a frequency of 22MHz, meaning 50MHz - 22MHz = 28MHz output. To allow the converter to be calibrated to obtain the exact frequency, a regulable condenser of 40pF (C7) is added to the oscillator. With this you can vary the termination frequency of the converter +-300 Hz.

Without much adapting you can also use the more currently available 24MHz crystal, but then the termination frequency of the converter will be 26MHz ipv 28Mhz (24MHz LO + 26MHz OUT = 50MHz IN).
The Gilbert cell is a differential amplifier which has balanced cell feeds. The differential gives extra gain and stipulate the noise number as well as the strong indicator behaviour of the recipient/converter. And these processes values up to -199dBm with 12dB S/N ratio. The symmetrical RF input (pin 1 and 2) has internal bias, thus we avoid external DC bias (to see C10 and C15)! THE RF input amount to capacitantie 3pF. There we connect single-ended coordinated LC-kring with parallel a resonance a frequency of 50MHz. These can peaked to best reception with C9. This is done best on a frequency where we want best sensitivity, for example 50,220 MHz. To start, move C9 in the middle position. When we have wound the coil L1 correctly, C9 does not need much to be adjusted. If there is no station to tune in to, then regulate C9 till you hear maximum noise.
To have a 50 ohm input by means of C7 and a tap at 1.5 turns from the cold end of the coil. Of course you'll need on 50MHz tuned antenna too HI.
The sensitivity of the converter amounts to 0.22uV at 12dB SINAD. Third-order the intercept point is -13dBm. This is approximately +5dBm output interception because of the RF gain.
The mixer has an internal DC-bias, by means of we connected the output (pin 4 and 5) with a 1k5 resitor to Vcc. Disengaging of the bias happens by means of C16, since we exploit here only a single termination instead of a balanced output. A balanced output will improve something, but to keep the schematic diagram simple, I have not applied this.
To allow only the 28Mc signal to pass through to T1 and into your radio I added a bandpass filter made out of C16,C17,L2 and C18. How crazy it may sound it actually improved the gain too.
The termination capacitance of the mixer (pin 5) amounts to 1.5kOhm. Given the termination indicator and the RF output voltage is a bit on the low side to connect directly to the recipient (radio), there is a amplified step to added which exists from a single BC547 transistor and als serves s a buffer between your receiver and NE602. With P1 one regulates the termination level (amplification) of the converter according to the entrance sensitivity of your communication receiver. The ideal setting is when we have the best singla/noise ratio. For the most the centre setting of P1 should be sufficient. An signal/noise ratio improvement can be made by using dual-gate mosfet ipv BC547(or BC338). The noise number of SA/NE602 is 4,6dB at 20°C and T1 ads its own noise level to it, as a result we end up with an average noise number of approximately 5dB.

C18 and L2 acts like a bandpass in this schematic. It passes signals approx. 26...30MHz. If using another LO frequency it could be needed to tweak C18. So it isn't a bad idea to uses a variable capacitor (trimmer) to fine tune the bandpass in this case.



More about the SA602 (NE602, SA612) in this project

The SA602A is a Gilbert cell, an oscillator/buffer, and a temperature compensated bias network as shown in the equivalent circuit. The Gilbert cell is a differential amplifier (Pins 1 and 2) which drives a balanced switching cell. The differential input stage provides gain and determines the noise figure and signal handling performance of the system.
The SA602A is designed for optimum low power performance. When used with the SA604 as a 45MHz cellular radio second IF and demodulator, the SA602A is capable of receiving -119dBm signals with a 12dB S/N ratio. Third-order intercept is typically -13dBm (that is approximately +5dBm output intercept because of the RF

gain).
Besides excellent low power performance well into VHF, the SA602A is designed to be flexible. The input, RF mixer output and oscillator ports can support a variety of configurations provided the designer understands certain constraints, which will be explained here.
The RF inputs (Pins 1 and 2) are biased internally. They are symmetrical. The equivalent AC input impedance is approximately 1.5k || 3pF through 50MHz. Pins 1 and 2 can be used
interchangeably, but they should not be DC biased externally.
The oscillator is capable of sustaining oscillation beyond 200MHz in crystal or tuned tank configurations. The upper limit of operation is determined by tank "Q" and required drive levels. The higher the "Q" of the tank or the smaller the required drive, the higher the permissible oscillation frequency. If the required LO is beyond oscillation limits, or the system calls for an external LO, the external signal can be injected at Pin 6 through a DC blocking capacitor.
External LO should be at least 200mVP-P. It is important to buffer the output of this circuit to assure that switching spikes from the first counter or prescaler do not end up in the oscillator spectrum. The dual-gate MOSFET provides optimum isolation with low current. The FET offers good isolation, simplicity, and low current, while the bipolar transistors provide the simple solution for non-critical applications. The resistive divider in the emitter-follower circuit should be chosen to provide the minimum input signal which will assure correct system operation.

Notes:
Tune to the desired bandpass frequency (50Mc) with C9 until you have the best reception.
Use C12 to calibrate the output frequency to your receiver. The output frequency can be adjusted up to 300Hz.
The output HF-level can be adjusted with P1. Regulate it according to the sensitivity of your receiver.

Other output frequencies can be set by changing the 22MHz Xtal: Example: output frequency is 26 MHz then you use a 24 MHz Xtal (50MHz - 24MHz = 26MHz).
Build the converter in a metal box and use small connections between the parts.

Important: use only a antenna designed for 50MHz! A simple dipole of around 3 meters in length (two times 1,45 meters) will work just fine if the propagation is there. Look at my homebrew site for a 3-element beam that works much better then a dipole and gives more gain, or a my 1/2 lambda vertical antenna.

More info about the 50MHz band (6 meters, the Magic band...) can be found at my site at MagicBand or Radioamateur Info.

PCB:
A PCB has been designed for this project by ON1MFW. E-mail me for detailed high resolution image of the PCB. Example: PCB-parts side PCB layout

Detailed information and manual (in Flemish (Nederlands)) ON6MU's 50MC CONCVERTER MANUAL

Technical graphs:

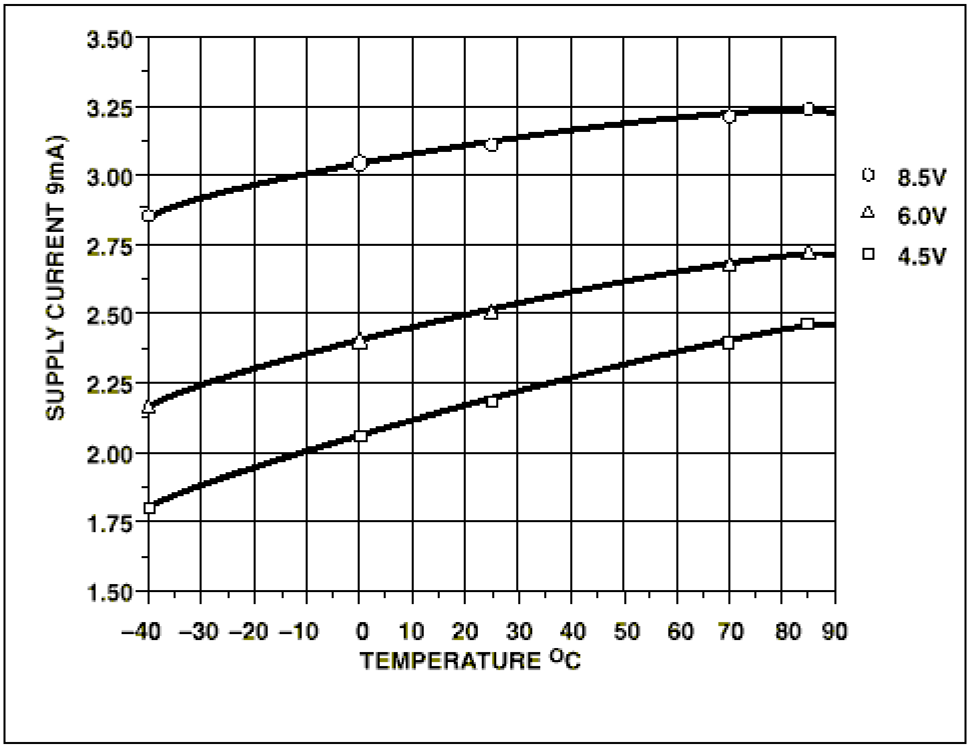


Figure 2. I_{CC} vs Supply Voltage

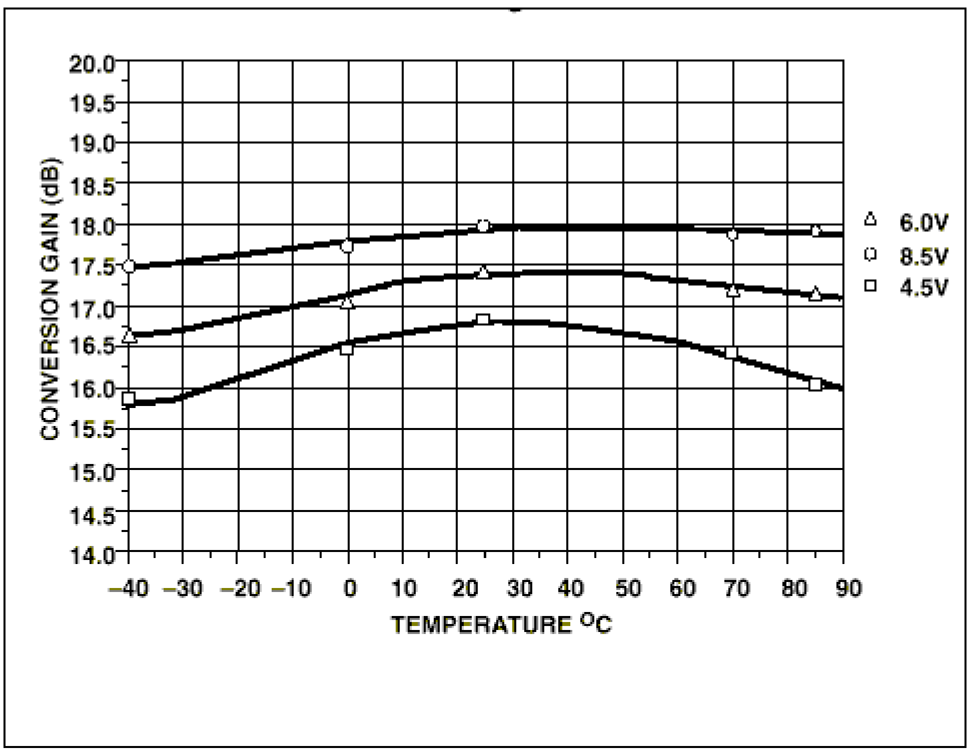


Figure 3 . Conversion Gain vs Supply Voltage

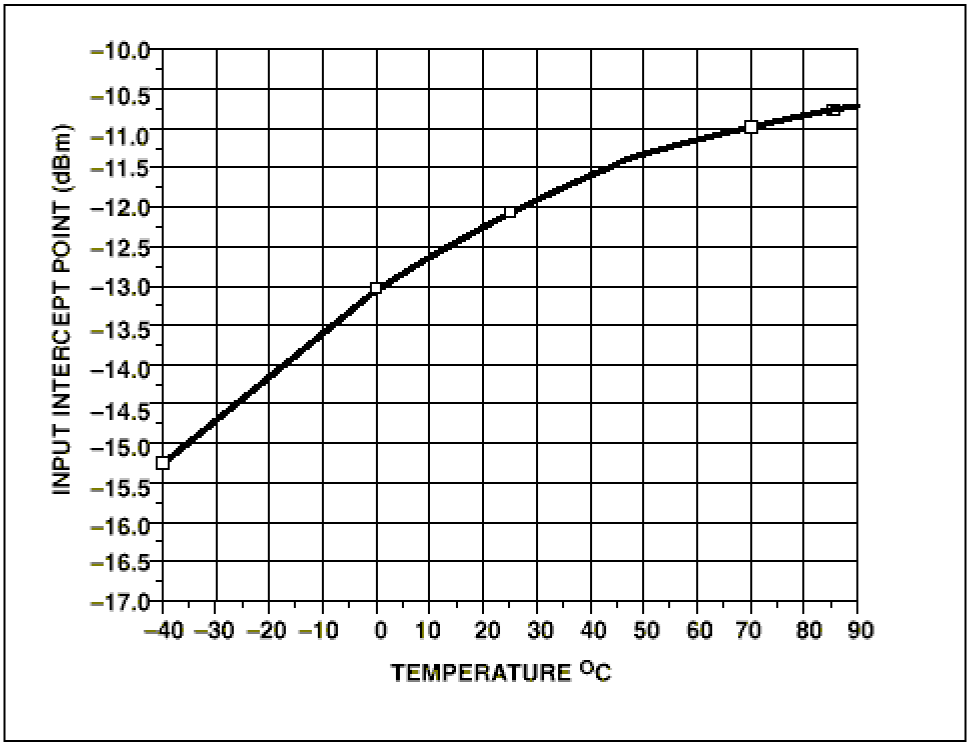


Figure 4 . Third-Order Intercept Point

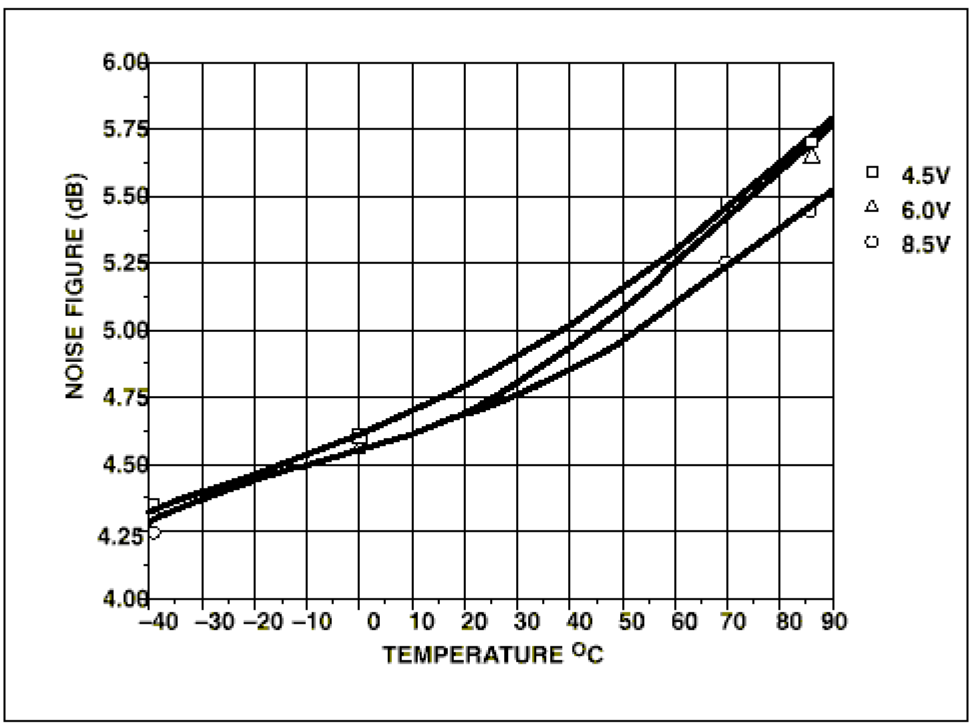


Figure 5. Noise Figure

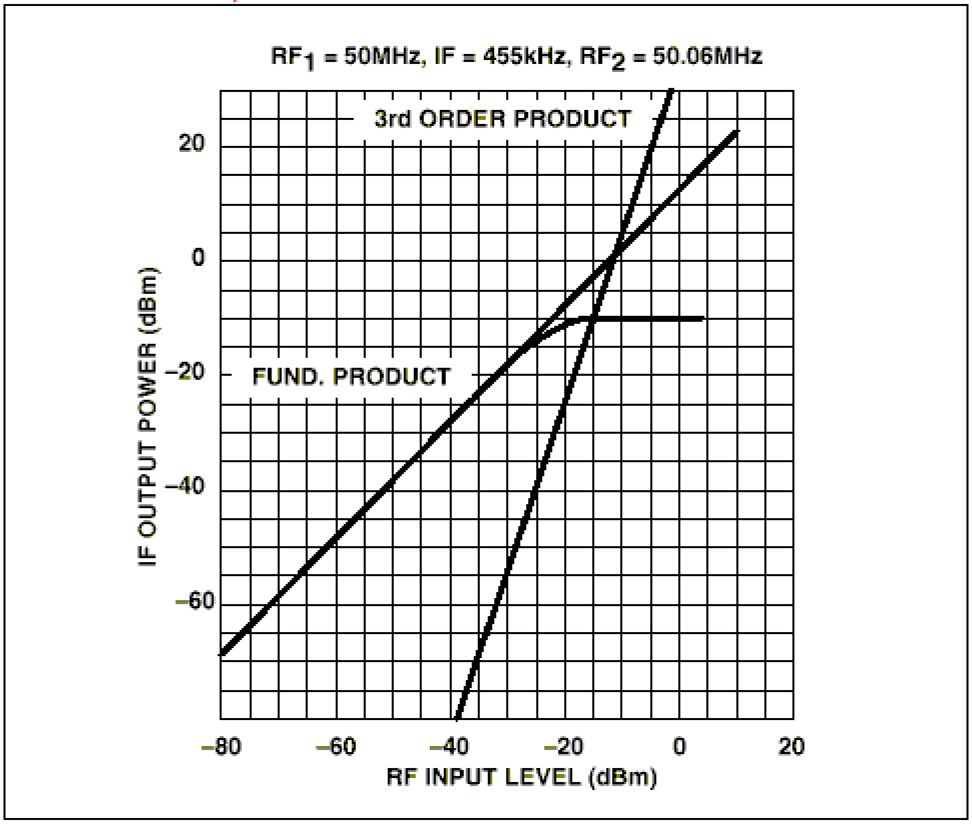
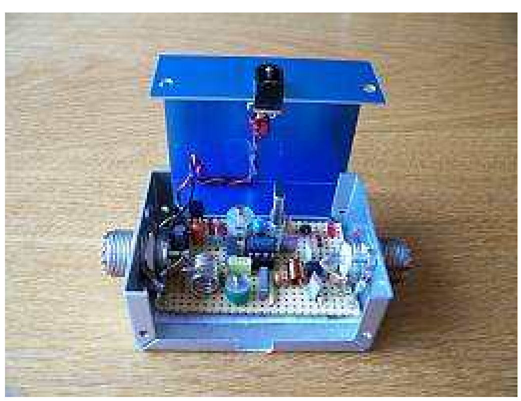


Figure 6. Third-Order Intercept and Compression

This project has been published in CQ-QSO (in Dutch and French) the ham-radio magazine of the UBA. Magazine 06-07/2000 pages 14,15,16 and 17.

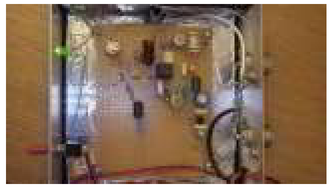
Afdrukken van dit project

More about his:



How Geoffrey F4FVI made it:






Thanks Geoffrey for the pictures!

My E-mail

Note: if you want to commercialise, publish or distribute this project then you need to ask permission to do so.

[home]

[mail] [shack] [homebrew] [software] [satellite]
[haminfo] [mods]

Back to ON6MU **Homepage**

ON6MU

QRP AM(cw) Transmitter for the 20 meterband RE-TX02HF20

By Guy, de ON6MU

Revision v1.3 (May 2012)

About the QRP AM/cw 20-meter band transmitter

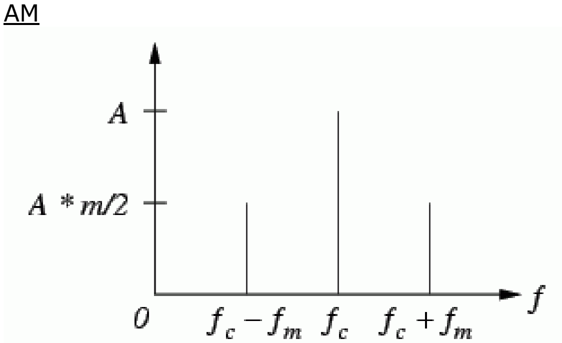
In this project, you will make a simple low-power broadcast-type circuit, using a crystal oscillator integrated circuit and an a collector modulated AM oscillator. You can connect the circuit to the an electrec microphone (pointed out in gray on the diagram) or amplified dynamic microphone (no amplified microphone has a to low output voltage to work. Approx. 100mv is needed). You could also add a LF preamp stage of one transistor to allow connecting a dynamic microphone directly.

You'll see that you can receive the signal through the air with almost any AM radio receiver. Although the circuits used in radio stations for AM receiving are far more complicated, this nevertheless gives a basic idea of the concept behind a principle transmitter. Plus it is a lot of fun when you actually have it working!
Remember that transmitting on 20 meter band you'll need a valid radioamateur license!

A wide range of different circuits have been used for AM, but one of the simplest circuits uses collector modulation applied via (for example) a transformer, while it is perfectly possible to create good designs using solid-state electronics as I applied here (T2 BD135).

The transmitter is build as a Colpitts Oscillator with a strong 2N2219(A) transistor. HF-output of the oscillator is 400 to 600 mW, depending on the supply voltage of 10 to 15 Volts. The transmit frequency is stabilized with the 14.3Mhz crystal which can be bought in almost any electronicparts shop. A slight detuning of approx 2kc is possible by using C11 trimmer capacitor. The oscillator signal is taken from the collector of T2 by induction and via a low-feedthrough filter and guided to the output via an L-filter circuit cleaning up the signal pretty good. The oscillator is keyed by T1 and the morse key (S). By keying the morse-key T1 is not been used for modulation and is biased, hence lets T4 freely oscillate.

AM



The resulting AM spectrum using sinusoidal carrier and modulating waveforms.

Amplitude Modulation (AM) is a process in which the amplitude of a radio frequency current is made to vary and modify by impressing an audio frequency current on it.
This was the first type of modulation used for communicating signals from one point to another and is still the simplest to understand.
A radio frequency current has a constant amplitude in absence of modulation and this constant amplitude RF carries no information, i.e. no audio intelligence and is of no use to radio telephone (voice communication), but has application in morse code communication.

In its basic form, amplitude modulation produces a signal with power concentrated at the carrier frequency and in two adjacent sidebands. Each sideband is equal in bandwidth to that of the modulating signal and is a mirror image of the other. Thus, most of the power output by an AM transmitter is effectively wasted: half the power is concentrated at the carrier frequency, which carries no useful information (beyond the fact that a signal is present); the remaining power is split between two identical sidebands, only one of which is needed.

CW
CW is the simplest form of modulation. The output of the transmitter is switched on and off, typically to form the characters of the Morse code.
CW transmitters are simple and inexpensive, and the transmitted CW signal doesn't occupy much frequency space (usually less than 500 Hz). However, the CW signals will be difficult to hear on a normal receiver; you'll just hear the faint quieting of the background noise as the CW signals are transmitted. To overcome this problem, shortwave and ham radio receivers include a beat frequency oscillator (BFO) circuit. The BFO circuit produces an internally-generated second carrier that "beats" against the received CW signal, producing a tone that turns on and off in step with the received CW signal. This is how Morse code signals are received on shortwave.

Although this design is primarely designed for AM, it can be used for CW by keying S.

RF Oscillator
Is been carried out by T4 (NPN 2N2219). This is the stage where the carrier frequency intended to be used is generated by means of Crystal Oscillator Circuitry or capacitance-inductance based Variable Frequency Oscillator (VFO). The RF oscillator is designed to have frequency stability (Xtal) and power delivered from it is of little bit more importance, although it delivers 600mW@12v , hence can be operated with low voltage power supply with little dissipation of heat. However, here we use the oscillator for a bit more power and so it does neet a heat sink.

You could add a switch (very short connections if using an ordinary switch) to select different Xtal's (frequencies). You could also use a more effective diode-based switch I've build here. This hasn't got the problems with longer connections at all.

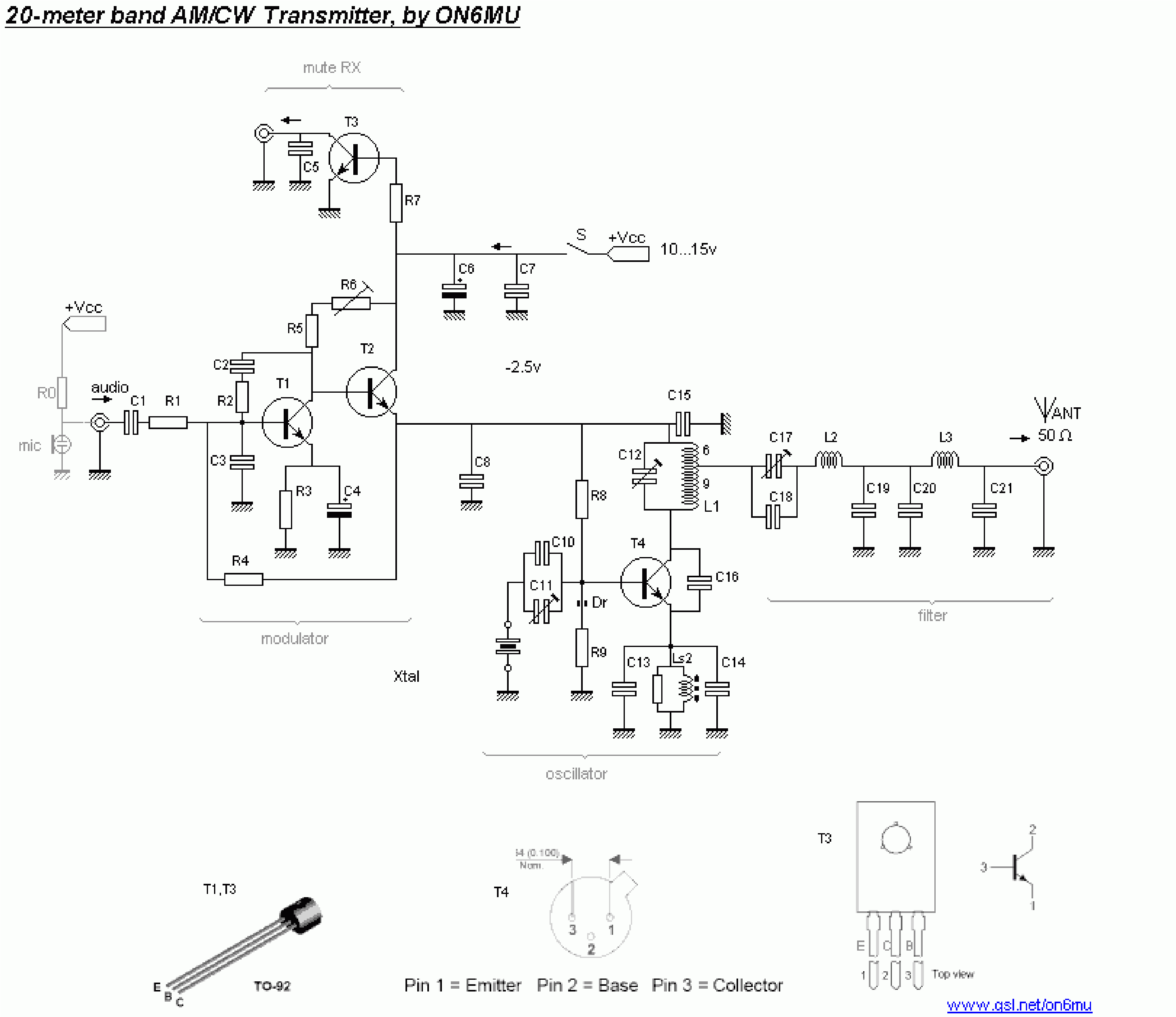
Filter
RF power amplification is also done here and this stage is coupled to the antenna system through antenna impedance matching circuitry (L1/L2/L3). Care is taken at this stage so that no harmonic frequency is generated which will cause interference in adjacent band (splatter) on other bands (C17...C21). This 3-element L-type narrow bandpass filter circuit and a low-pass filter for the desired frequency cleans out any remaining harmonic signals very efficiently hence good spectral purity.

Modulator
Is done by T1 and T2. Audio information is impressed upon the carrier frequency at this stage. Do to selective components circuits (C1,R1,R2,C2,C3,C4,C8) the voice component frequencies are enhanced, whilest others are suppressed (bandwidth +- 3kc/side) keeping it between HAM-radio specs.

Why over modulation is not desirable?..
Over modulation is not desirable, i.e. modulation should not exceed 100 %, because if modulation exceeds 100 % there is an interval during the audio cycle when the RF carrier is removed completely from the air thus producing distortion in the transmission.

Housing/shielding
The whole circuit needs to be mounted in an all-metal/aluminum case. If you're unable to obtain an all-metal case, then use a roll of self-sticking aluminum tape (available from your hardware store) or PVC box painted with graphite paint. Just make sure that all individual pieces of aluminum-tape (or the graphite paint) are conducting with each other. Works fine.

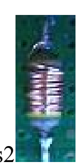
Use it with your receiver
If you put a relay, or better a transistor switch to mute your receiver (if equiped) you can easily make a QSO HI. A simple BC338, Bc547, 2N2222 (T3) at pin a" with the base biased with a 100k resistor, emmitor at the gnd and the collector fed to your receiver's mute input works fine. Or you can use a 12v relay... Every time you PTT the transistor (or when using a relay, the switch) is "shortened" between the ground, hence muting your receiver (again; if your receiver has mute capabilities).



Parts list 20-meterband transmitter

- T1 BC338, BC337
- T2 BD135 (with heatsink)
- T3 2N2222, BC338
- T4 2N2219A (with heatsink)
- C1 220nF (polyester) rev1.2
- C2 1500 pF (polyester) rev1.2
- C3 10nF (polyester) rev1.2
- C4 47uF/25v
- C5 100nF
- C6 100uF/25v

- C7 100nF
- C8 100nF
- C10 12pF
- C11 120pF (frequency offset +- 2kc)
- C12 0...18pF (peek at design frequency Xtal)
- C13,C14 330pF
- C15 470pF
- C16 47pF
- C17= 6...40pF (white) set at half position and tune to max power
- C18 22pF
- C19 180pF
- C20 220pF
- C21 150pF
- R1 1k
- R2 3k3
- R3 120
- R4 560k
- R5 560
- R6 100 (pot. to set power/modulation ratio +/- 50mW according to applied voltage)
- R7 100k
- R8 4k7
- R9 560
- L1 = 0.8mm Cul (insulated copper wire), 15.5 turns close together, 7mm inside, tap at 6.5 turns
- L2 = 0.6mm Cul (insulated copper wire), 24 turns close together, 8mm inside diameter
- L2 = 0.6mm Cul (insulated copper wire), 8 turns close together, 8mm inside diameter
- Ls2 = 470 1/2 watt carbon, 0,2 Cul turned 5 times over the entire length of the resistor (+/- 10uH)
- Dr = small ferrite core with a few turns of 0,2 Cu (or the spare wire of R5 turned a few times through the core)
- 14.310Mc Xtal (or other for your desired frequency) +- 2kc with C11
- C1, C2, C3, C8 polyester film capacitor

Ls1, Ls2 

Revision 1.1
Filter unit efficiency peaked by changing C19 & C20
BIAS T4 improved by changing R9 + adding ferrite in series

Revision 1.2
Audio modulation spectrum and linearity improved (changing C1,C2,C3)
Revision 1.3
Ls1 coil removed, C9 removed (extra choke was not needed)

Note:
Always use a dummy load for testing and adjusting the transmitter!!!

Specifications

- Peak Frequency range: 14Mc...14.5Mc
- Output RF power: 600mW pep @ 12v
- AM modulated +/- 85% (CW if keyed)
- Adjustable output impedance to 50 Ohms
- Band-pass type harmonic L-filter + lowpass PII
- Usable voltages: Vcc 9 - 15 volts
- Average current I: 140mA@12v
- Xtal oscillator,
- Adjustable frequency of 2Kc
- LF input +/- 100mV @ +/- 4k

Antenna's

It's important to use a correct designed antenna according to band you would likt to operate, or at least a good tuned antenna using a matcher (protecting your transmitter). Several examples can be found on my website and all across the Web. A dipole is always a good alternitive (total length = 150/freq - 5%).
The performance (distance relative to you RF power) of your transmitter/transceiver is as importent (if not more) as the RF power you transmit! A dummy load gives also a perfect 1:1 SWR, but you wont get any farther then the street you live in HI. Finally, athmospheric conditions (D-,E-,F-layers depending on the frequency you're using) is as important as all the above.

Related

Remember that transmitting on the 20 meter band needs a valid radioamateur license!

Another related project: 10 meterband transmitter project

ON6MU
Home

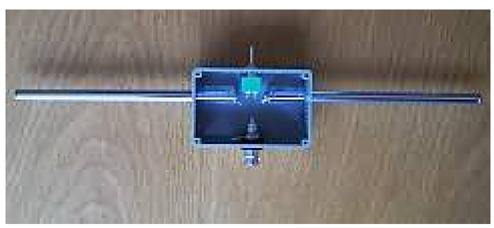
VHF/UHF Wideband Portable Dipole

RE-A6270D12P

ideal for the FT-817 etc.

By Guy, de ON6MU

I wanted a robust, portable, compact antenna usable for horizontal and vertical polarisation to take along with my FT-817 when I go on vacation, camping etc. I also wanted the dipole to cover the VHF and UHF bands and if possible with some gain! As everybody knows a dipole has about 3dB gain over a quartre wave antenna, is why my preference went to a simple dipole. To make it portable I used two identical telescopic antennas of 80 cm slid out and only 14 cm when pushed in.



What you need to make this handy portable wide band dipole is:

- Two chrome-plated telescopic antenna's (14cm/80cm)
- A robust PVC box of 75x50x22 mm and 1,5mm thick
- a silver plated stereo mini switch
- a professional female BNC connector
- some low loss RG174 50 Ohm coax
- carbon/ferrite bead or toroid (to act as a shoke)
- some 0,6mm enamelled copper wire to make the coils (like from a transformer)
- a small ferrite core to place in L2 (approx 4 mm diameter)
- glue gun and/or silicone

BNC -------------------------- silver plated switch

carbon based bead ------  RG174 thin low loss coax

chrome telescopic antenna ABS plastic anti-static box

I did not find a telecopic antenna small enough to reach 450 MHz and still long enough to reach 50 Mhz (1,5 meter), so the only sollution was to tune the dipole (made out of two 80 cm telecopic antennas) for 50Mhz using two coils (base loaded dipole). A double silver plated switch is used to shorten the coils when using it for frequencies above 50 Mhz. The gain when using the coils (loaded dipole to get a shortened dipole) on 50Mhz is approx. the same as a quartre wave, meaning no gain.

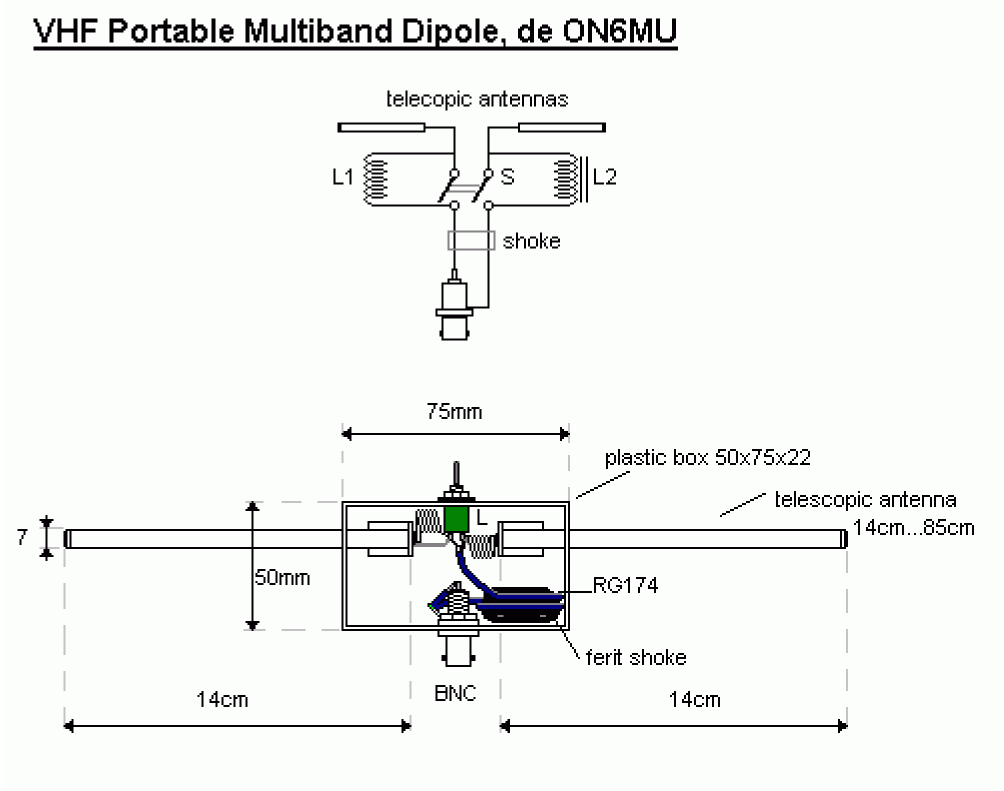
You can use any size of telecopic antenna, but just beware that the minimum length determines the highest frequency and the maximum length of the telescopic antenna determines the lowest usable frequency!
In my case, using a 14cm/80cm telescopic antenna, I calculated the working frequency range:

- 90MHz to 470MHz (switch closed)
- 48MHz to 90MHz (switch open)

You can tune the dipole to the desired frequency by sliding both telescopic antennas in or out.

This little antenna could also be used for satellite as the dipole tuned to 145 MHz works reasonable well on RX @ 435 MHz.

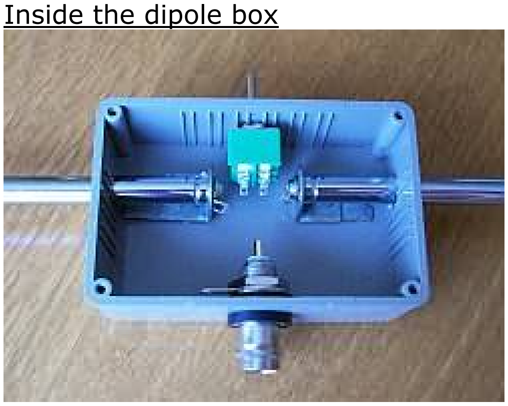
Links of interest:



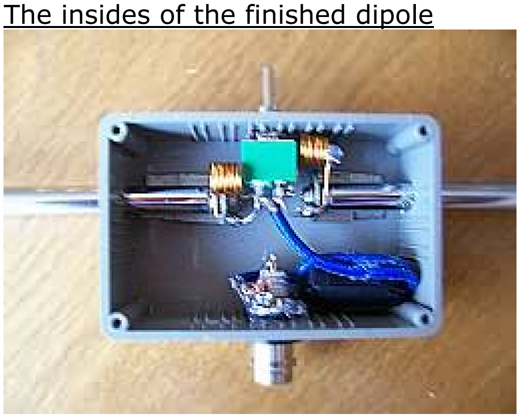
The coils

We need two pieces of emalled 0,6mm copper wire (stripped from a transformer will do). Wind the wire around a 5,5 mm drill till you get 8 turns. Both coils are exactly the same with one exception: in the coil mounted on the ground side (L2) we put a little ferite core inside the coil and seal it with some glue. When the switch S is open they will allow you to use the dipole on 50Mhz when both telescopic antenna's are in full length (2 x 80 cm).

Inside the dipole box



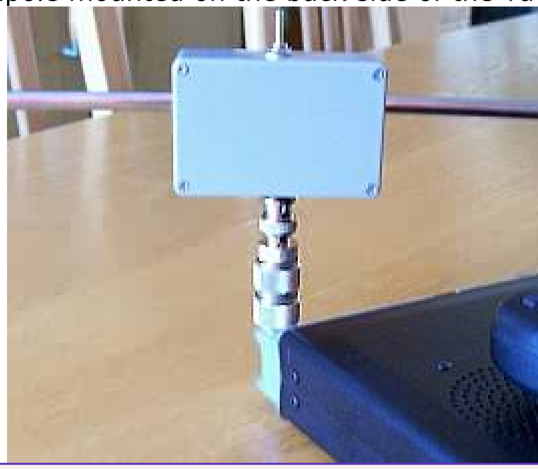
The insides of the finished dipole



After you tested the dipole you can finish it by using your glue gun tor silicone) to seal everything up.

The maximum TX power is approx. 10 watt.

Finished dipole mounted on the back side of the Yaesu FT-817



Jeff, AJ8P sent me a few pictures:

....

....

Thanks Jeff!!

Home
www.qsl.net/on6mu

ON6MU

"MUrDuck" VHF "rubber duck" Portable Antenna

RE-A144V1P

de ON6MU

You can make your own 2-meter "rubber duckies" that will likely perform much better than many commercial units. I compared my design with two other "rubber duckies" of the TH215 and ICT7 which outperformed them both. With the "duckie" of the ICT7e as much as 10dB. It does not has a gain compared to a 1/4wave antenna ofcourse, but compared to most standard "rubber duckies" its average "gain" is about 6dB (or more). This has several reasons:

- You can tune it for optimal SWR/performance and to the centre frequency you desire (factory duckies are mass-produced and their SWR isn't always good. The TH215 antenna had an SWR of 1:1,4 and the ICT7 dualband antenna was 1:1,6 SWR)
- The coil is much much better and has a higher Q (less loss)
- The effective antenna length is 24 cm (about 10 inches = 1/8wave)
- Performs much better and cost way less then a commercial one!
- Can handle more power (isn't that important for HT's, but nevertheless...an advantage.)
- Better radiation pattern
- You can build a replacement antenna that delivers a lower SWR and more RF output than the one that came with your radio, and you can do it for 10euro or less and a couple of hours of fun! And...It's educational, it's HAM-radio and what's more fun then using your own homemade antenna and to see it out-perform most commercial "duckies" HI.

This design is based on using a maximum applied RF power of 15 W at 144 to 148 MHz.

To test and tune you need:

- A accurate SWR/Power meter and field strength meter
- A HT or low power transceiver and some coax with the proper connectors

BNC

Half finished

TH215 duckie

Results in practice, tested at five different positions:

Position	ICT7e ant (10cm)	MUrDuck 1/8 wave	Kenwood 1/4 telescopic ant
A	S 4	S 9+	S 9+6dB
B	S 7	S 9+12dB	S 9+15dB
C	S 3	S 8	S 9
D	S 5	S 8	S 9
E	S 9+6dB	S 9+20dB	S 9+30dB

Transmitter: Icom ICT7e @ 0,5 watt
Location: City, inside building, 1Km

Receiver: Kenwood TM255
Location: City, 2x5/8 comet @ 18mASL

Conclusion: Our "MUrDuck 1/8 wave duckie" performs much better then the standard Icom ICT7e dualband duckie but does not beat a the quarter wave Kenwood dualband telescopic antenna. Although the results between the quarter wave and the "MUrDuck" are very close, the measurements between the factory ICT7e duck-antenna are quite impressive!
Note: the S-readings are not calibrated readings!!!

What you need to build the MUrDuck (RE-A144V1P):

- some copper electrical installation wire of 1mm diameter
- some "left-over" 3cm 5/8" PVC pipe
- a piece conducting material of 25cm in length,
  like: thick flexible electrical installation wire, RG58, Aircell+, 5mm(or more)earthwire,...
- a male BNC-connector (I used a BNC to Cinch connector)

Wind 5 turns of 1mm wire around a coil form of 10mm diameter, keeping the turns about 0.5mm apart. This will fit snugly into the 5/8" PVC tube.

The is coax soldered to the coil and the coil is soldered to the centre pin of the BNC. Solder it to the coax (if you use a coax as antenna): The center conductor and the shield of bothe sides of the coax is connected together. Cut if needed (optimal SWR). Mine was cut to 24 cm.

To Test

For optimal performance, use a VHF SWR/power meter and a field-strength meter to tune the antenna. If you don’t, your
homemade antenna may still work at least as well as the factory antenna. I used a Daiwa SWR meter and a "homebrewed" field-strength meter positioned about eight feet away from the transceiver. Connect your new antenna to the SWR/power meter using the proper combination of connectors.

(A right-angle SO-239 adapter and a PL-259-to-female BNC adapter worked for me.)

Attach the radio’s antenna output to the SWR meter’s transmitter input with a 60cm (or shorter) length of coaxial cable.
Adjust the field-strength meter’s location and its antenna for a mid-scale reading.
Connect your commercial rubber ducky to the SWR/power meter and check the antenna’s performance; log your measurements.
Those are the numbers you’re going to beat. We’re looking for minimum SWR, maximum power and maximum field strength.

Now, attach your homemade antenna to the SWR meter. Check the antenna’s SWR and field strength. Gently adjust the
vertical position of the whip until there is an improvement in the readings if needed. Try squeezing the coil turns closer to each other which influences the SWR too. Continue making adjustments until the readings are optimized.

Once you are satisfied, run a bead of glue around the base of the whip. Place
the 3cm 5/8" PVC pipe over the coil, overlapping both ends of the coil form and leaving enough space to push in the BNC connector and room to fill the rest up with glue of a glue-gun.

You can see the BNC-connector which is pushed in the PVC-pipe by carefully heating up the end of the 3 cm long PVC 5/8" tube. After checking the SWR it's filled with glue from a glue-gun which gives it the solid-state and durable finish (and watertight).

I've managed to get the SWR to 1:1!

A few last things to note. A small antenna such as a rubber duck antenna (or even a mag-mount antenna) attached directly to a radio will give different results based on the size of the radio, what's connected to it, and the things around it. The reason for this is that the antenna tuning is affected by the "counterpoise", which in the case of a rubber duck is the radio itself. (If the antenna is outside or better isolated from the radio, the readings should be the same.) Since things like rubber ducks won't be the same with an outboard SWR meter connected or the same as an antenna analyzer might show, the only way to know what the SWR is for a particular radio and frequency with a particular configuration of power supply, microphone, people etc, is to read the SWR off the radio. Of course if that's not accurate, you're not getting the right information.

More of interest:

The Telescopic MurDuck RE-A144V2P

Same principle, but using a telescopic antenna of 30 cm in length. Being telescopic it can be used for more then one frequency. I also put a 3 pF capacitor inside the coil and soldered on both ends of the coil (making it parallel resonant). The "block" frequency lies way out of the VHF or UHF HAM bands. 144...148 or 420...440mc are easily passed through, making it dualband. The frequency that's being blocked is about 290 Mc +/-.
Instead of a BNC connector I used a SMA connector.

Coil dimensions: 6.5 turns, 4mm inside diameter, 0.6mm wire (+/- 100nH)
Inside the coil: a 3pF capacitor


finished

I used a SMA connector for use with my Yaesu VX-1. The included "petite" rubber duck isn't worth much. This has made a huge difference not only for VHF/UHF, but also outside the ham-bands as this little VX-1 thingy has wide reception.

To test and tune your telescopic dualband antenna the same principles described above (MurDuck) applies here too.

The tank resonance formule: 2*pi*F= 1/sqrt(L*C) => 291 Mc block frequency

Have fun and my best 73"

Guy, ON6MU
http://www.qsl.net/on6mu

Home
www.qsl.net/on6mu

ON6MU

Installing the N4YG DDS in a Ten Tec Omni D

By Pete Juliano
radioguy90@hotmail.com

Every once in a while luck finds a path to our door and it was with such a lucky happening that I purchased a Ten Tec Omni for $90. The radio had a few technical problems which were resolved in about 15 minutes at no cost and a simple cleaning of one contact. Lucky me! In no time I was on the air and despite adequate warm up periods the PTO drifted some 100 to 200 Hz. In today's world that is unacceptable.

My first thought was to install an X-Lock-3 frequency stabilizer from Cumbria Designs in the UK. I have made three installations of the X-Lock in a HW-101, Corsair I, and a TR-7 so I know it works. But then there is the ever PTO rebuild scenario with the Ten Tec PTO's. So that solution was discarded in favor of installing the N4YG DDS board. Using that board not only provided a highly stable VFO source but it came with bonuses such as being prebuilt and tested, having an A, B and Split VFO functionality as well as variable rate tuning for very fast or slow QSY. Another bit of icing on the cake is that the board can be made to remember the last frequency when you power down. How great it is to be able to power up the radio and it already is on frequency. Finally an RIT function is embedded in the DDS board that gives about a +/- 1.5 kHz spread.

Thus started my journey of acquiring and installing an N4YG DDS. The website for the N4YG DDS is quite good and has much information

including several who proceeded me along this path namely AA4BQ and W0CCA. After several rounds of emails and profiting from the prior experience database, I considered the two options for installation. One is to physically install the DDS inside the Omni D and the other is an external install.

The internal installation most likely would require some shielding to prevent unwanted signal from entering the radio. Such was the case with one of the prior installations. Internal installation requires physically removing the PTO assembly, disconnecting wiring to the Spot switch and rewiring of the Offset pot. Installation of the DDS board itself requires drilling some holes in the Omni D sub-chassis. For those not so experienced in working on parts and assemblies in tight quarters this could prove to be a daunting task. The internal install also means that if for some reason the radio would be returned to stock, reversing the process while not impossible would once again take some experience and skill.

The other option is the external installation where the DDS would operate much like a remote VFO. That is the option I chose. This option is minimally invasive and requires pulling the VFO jumper on the back panel of the Omni D and inserting the output of the DDS into the RCA jack marked “VFO In”, a connection to +12VDC at the Auxiliary +12 VDC jack also located on the back panel and an internal connection to any board or control where there is an “R” voltage present. Three connections and that is it. A return to stock involves reinstalling the VFO jumper, disconnecting the +12 VDC and removing the connection to the “R” pin. One minute max is about all that would take. The internal PTO, and Offset selection are inactive using this method and everything is now done on the Remote DDS. Below is my DDS installation sitting next to the Omni D. The yellow wire is the temporary connection to an “R” location.

First some baseline information about the stock Omni D which is essentially a single conversion radio with a 9.0 MHz IF. On all stock bands except 20M, the 5.0 MHz PTO signal is heterodyned with various crystal frequencies to provide the proper injection frequencies. You will note that the Omni D as well as other Ten Tec Radios define their SSB operation as normal and opposite versus USB or LSB.

The reason for this is that below 20M the PTO + Crystal Frequencies are on the high side of the incoming signal which causes a sideband inversion (ie LSB) using the same Carrier Crystal for 20M and above the PTO + Crystal Frequencies are on the low side (on 20M there is no heterodyne crystal) so USB results. Clever approach. But in all cases the PTO tunes the same frequency range 5.0 to 5.5 Mhz. The DDS is merely substituting for the PTO with the added functionality as previously mentioned.

So what comes in the N4YG DDS kit? The complete kit includes the DDS board, the interface cables, high quality optical encoder, and 4 each mounting pillars. In my case N4YG threw in a few LEDS and some

dropping resistors. Since the premise of the kit is an internal installation the Omni D, the Spot Switch and Offset control would be pressed into service as a mode switch and RIT control. These are not used in the remote installation. Thus I had to supply a momentary Push Button Switch and a 25K pot for the RIT. I didn't have a 25K pot so I used a 100K Ohm pot bridged with a 33K Ohm ¼ watt resistor. The equivalent parallel resistance is 25 K Ohms.

The table below defines what is required to build the remote installation.

Item	Supplier	Comments
DDS Board	N4YG	
Optical Encoder	N4YG	
Cables/ Mounting Hardware	N4YG	
Spot Switch	Owner	Use a momentary from Radio Shack
25K RIT Pot	Owner	I used a 100K + 33k Bridging Resistor
Green LED	Owner	Standard Green LED from Radio Shack
Red LED's (2)	Owner	Standard Red LED from Radio Shack
LED Holder	Owner	Holder available from Radio Shack
Knob Large	Owner	I used a TT knob from an Omni VI
Knob Small	Owner	I used a TT knob from an Argosy
150 Ohm (3)	Owner	¼ watt from Radio Shack

Case	Owner	Surplus Power Supply Case from a TT 262G
Misc. Wire and Connectors	Owner	Junk Box.

The wiring instructions for the Corsair II were used for the install and that is where N4YG has done a super job at labeling the DDS Board connectors. Each wire is marked so it is clear what goes to where. In the case of the VFO A, B and Split LED's I used a 150 Ohm dropping resistor is series with the wire which are connected to the anode side of the LED (longer lead) and the cathode (shorter lead) of each LED is grounded. Larger values of resistance will make the LED less bright. I wanted the LED's to be in my

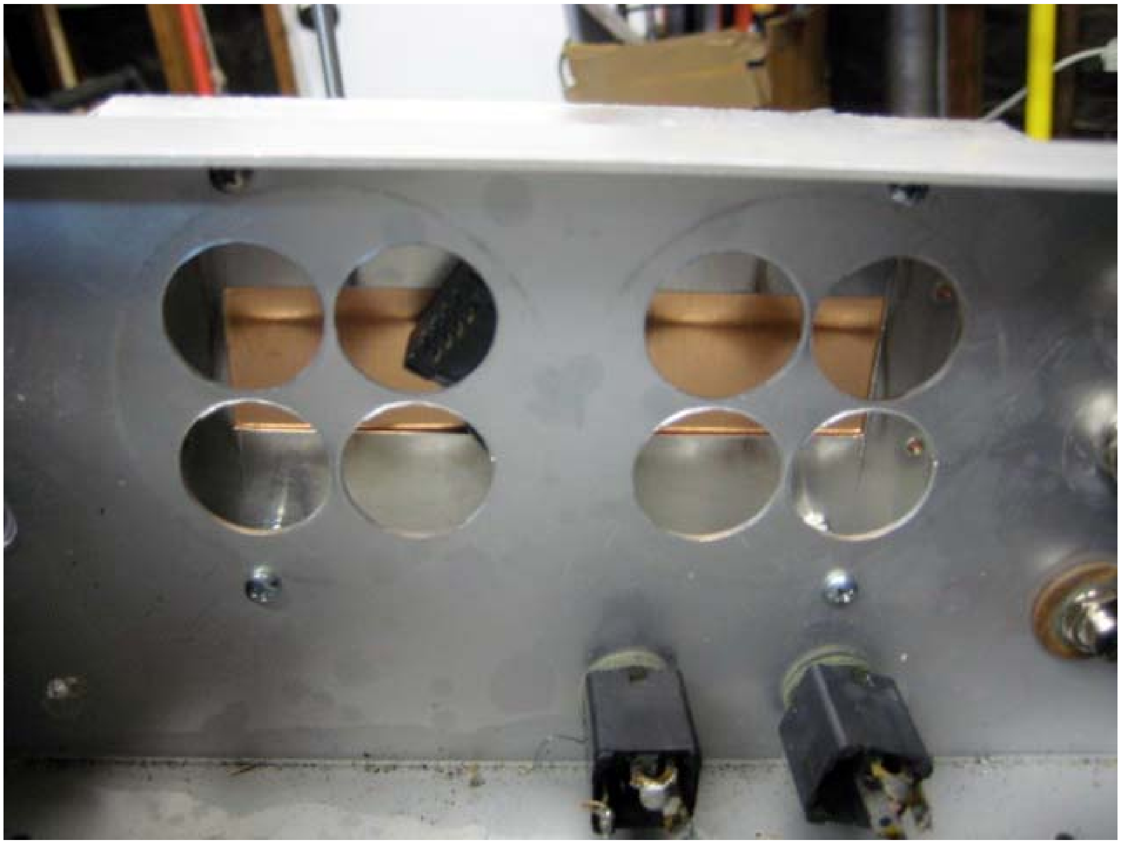
face and clear from a few feet away to clearly indicate which VFO was being used.

The N4YG DDS board is relatively small measuring some 3 inches by 3 inches and so there are many commercial enclosures that would work. That said having too small of a box will mean the remote DDS is moving all about the operating desk and anchoring the box to the operating desk does somewhat limit your flexibility.

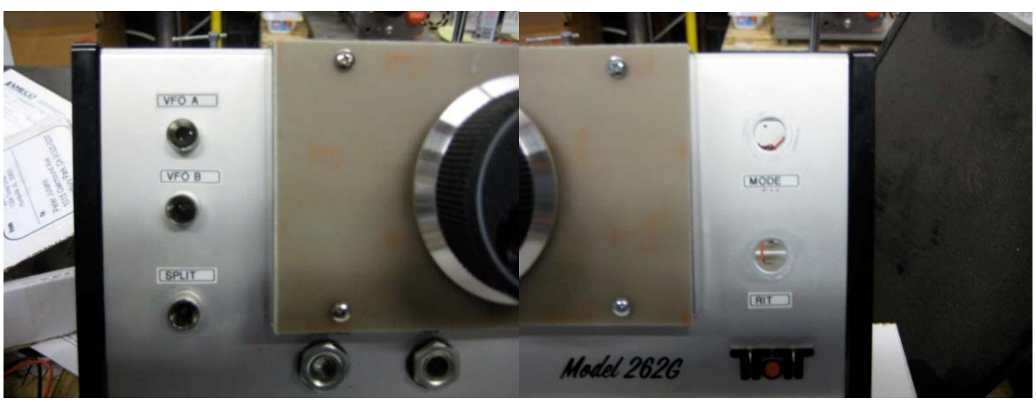
Enter the Model 262G TT enclosure. Several years ago I bought a Ten Tec Model 540 as a tech special which I modified to now have a digital display. When the Model 540 arrived there were two boxes and one included the Model 262 case which had been gutted and reused to have some sort of keyer built in. Thus I had a freebie case in the deal.

In looking at the case I could see where the front panel could be readily adapted for the DDS install. The Model 262G has two front facing speakers which are covered by a plastic frame and speaker grill cloth. Removing that reveals large holes in the front panel which would present some problems in the mounting of the optical encoder. My resolution of the problem was a sub-panel to mount the optical rotary encoder which is now affixed to the front panel. All of the other existing control and indicator holes were used without having to drill any additional holes. The 262G case may be a bit of an overkill in terms of space but it looks Ten Tec and is Ten Tec and so a perfect complement to the Omni D.

Following are some close up photos of the installation inside the 262G case

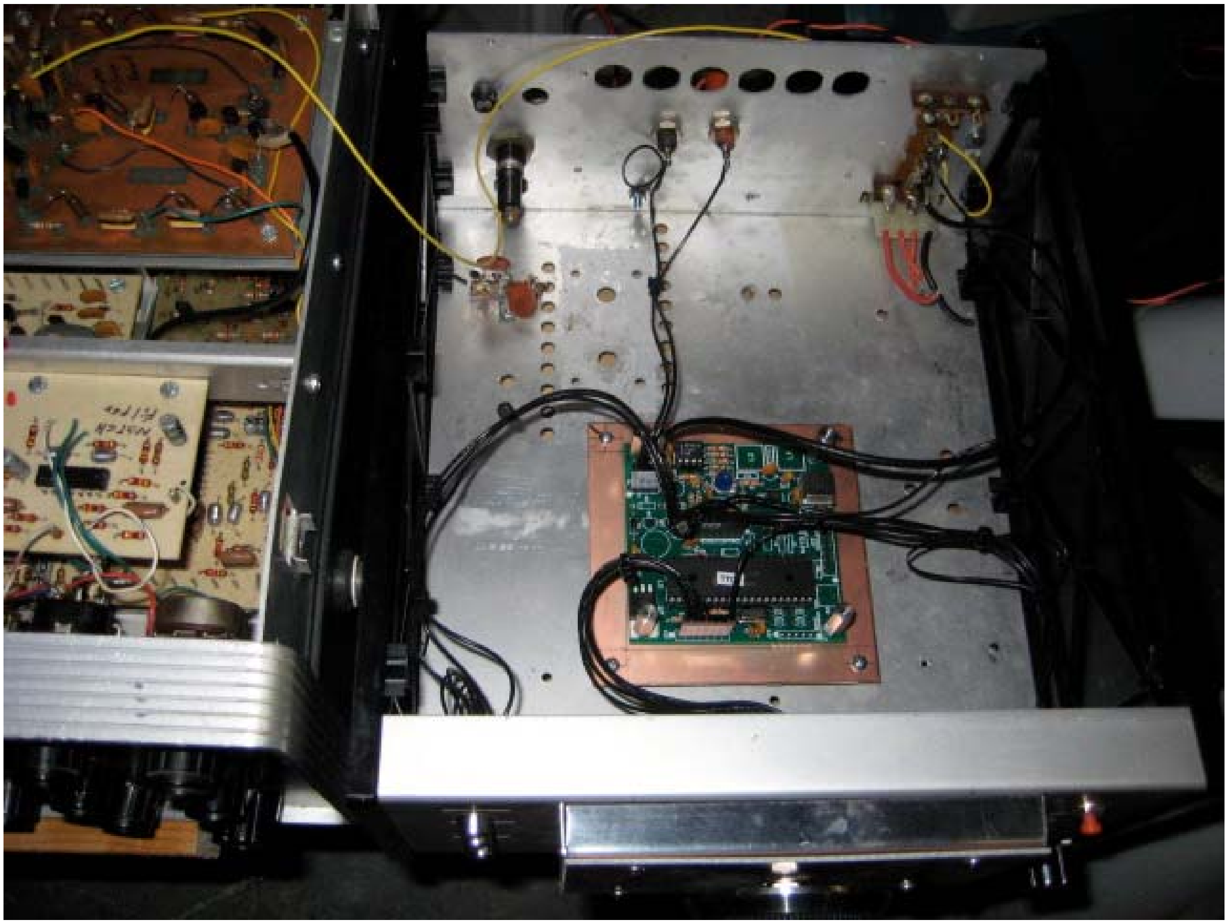


Backside of the front panel showing the encoder and the connection point



I have a small label machine from Brothers and made these labels which cover the original Ten Tec lettering.

Finally this is a photo of the internal portion of the 262G and how the DDS board was mounted internally. I purposefully mounted it in an open area and if required could add additional shielding around the board. That has not bee required.



A sub chassis of approximately 4 inches by 4 inches was cut from a piece of single sided copper PC board. The N4YG DDS board comes with four ¼ inch spacers which are used to mount the DDS Board on the Copper Board and provides a solid ground plane. The Copper Board is then elevated above the base of the 262G by four more spacers and thus provides a solid grounding to the Ten Tec case. Many of the back panel connections are reused to connect the input and outputs of the DDS board. There are two RCA jacks on the back panel both of which are floating and one of these is used to connect the RF Output of the DDS to the VFO Input port on the Omni D. I insured that the ground pin of the RCA Jack I used for the RF output was physically connected to ground.

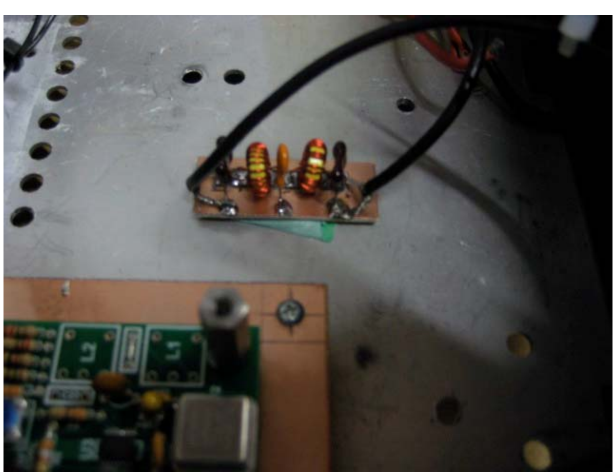
The DDS worked first time and I am happy with the result given the limitations of a 35 year old radio. The frequency stability is outstanding and

having the two VFO's and split operation puts in on par with the technology of today. Too bad more hams do not realize that with a bit of upgrading some of the old boat anchors can compete with the modern several thousand dollar radios of today. The total investment was less than $300 and it only took about 5 hours total to build the hardware and make the installation. Thanks Joe!

Refinement to the Installation

The Omni D, again a single conversion transceiver, uses crystal mixing to place the LO above or below the incoming frequency with the exception of 20 Meters where the LO is directly mixed with the incoming to achieve the 9.0 MHz IF signal. After a few days of operation I noted some "squeals and squeaks" only on 20 Meters which I quickly recognized as some possible harmonics of the DDS causing the issue. I have seen this before in several homebrew radios I have constructed and the cure was to insert a 5 MHz Low Pass Filter in line between the DDS and the Omni. The photo below, shows that installation and the parts values are 680 PF for the two outer capacitors, and 1000 PF (0.001 Ufd) for the center capacitor. The two inductors consist of 25 Turns of #24 on a T-37-6 powered iron core (yellow) form. This circuit is a lift from a project by W7ZOI published in QST in Dec 89 and Jan 90.

The Low Pass Filter did its job and so no more squeals and squeaks. I highly recommend that this be a standard installation feature for any Ten Tec applications.



De N6QW February 2014

PS: There is a youtube video showing the DDS in action with the Omni D

http://www.youtube.com/watch?v=WgdqXj5qeys&feature=c4-overview&list=UU4_ft4-oTdCMlWlL4XXHScg

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3 Band Portable Field Radio

Designed by Steve Weber. KD1JV

The updated PFR-3B now contains a rotary encoder and other minor changes to improve the performance.

Specifications

Bands : 40 meters, 30 meters and 20 meters
Tuning range: Full band coverage
DDS VFO with 50 Hz slow tuning rate and 200 Hz fast tuning rate
Mode: CW only

Receiver MSD: 0.2 uV typical
Selectivity : 300 Hz
Four crystal IF filter and 600 Hz center frequency audio band pass filter
Receive current, no signal typical:
Active, 47 ma
Idle, 34 ma

Transmitter:
5 watts at 12 volts, all bands +/- 10%
Transmitter current: 650 ma (40M) to 740 ma (20M) typical at 5 watts

Spurs: - 50 dBc maximum, all bands

5 to 40 wpm internal B mode iambic keyer
Two (2) 63 character keyer memories.

Coax or balanced line output
Built in SWR indicator and BLT (balanced line tuner)

Size: 7.2" long, 4.2" wide, 1.5" high (less knob height)

Power supply voltage: 8 volts minimum, 12.5 volts maximum. 12 to 9 volts recommended
External power or internal battery pack

Paddle Bracket

Pictured with American Morse DCP Paddles

- Attaches to any PFR3 (including A and B versions)
- Works with any of the the American Morse DCP, Porta Paddle, Mini-B, and MS-2 kits
- Includes cable and all needed hardware

Supporting Files and Documents

PFR-3B Manual

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enter email address

Powered by groups.yahoo.com

Ordering Information

To order this kit, use the buttons below. (you do not have to have a PayPal account to pay for items using a credit card)

Payments are Fast and Secure with PAYPAL

NOTE
Use Add to cart buttons to add an item to your shopping cart. Use "Continue Shopping" tab to go back and add multiple items to your cart. You can view shipping charges before making payment. Payment can be made by Credit Card, Debit Card or by Paypal. Selecting "Checkout" in your shopping cart will allow you to use a credit card rather than Paypal Please be sure the address you supply is correct. We receive an automated notification when you complete payment. Your order will be shipped as soon as possible unless otherwise stated. Thanks for your support!

PFR3 Transceiver: 275.00	Add
PFR3 Bracket: $25.00	Add
PFR3 Bracket with DCP Paddles: $70.00	Add
View your shopping cart:	Check Out

*Note: There is free shipping on the paddles when orderded with the **PFR3***

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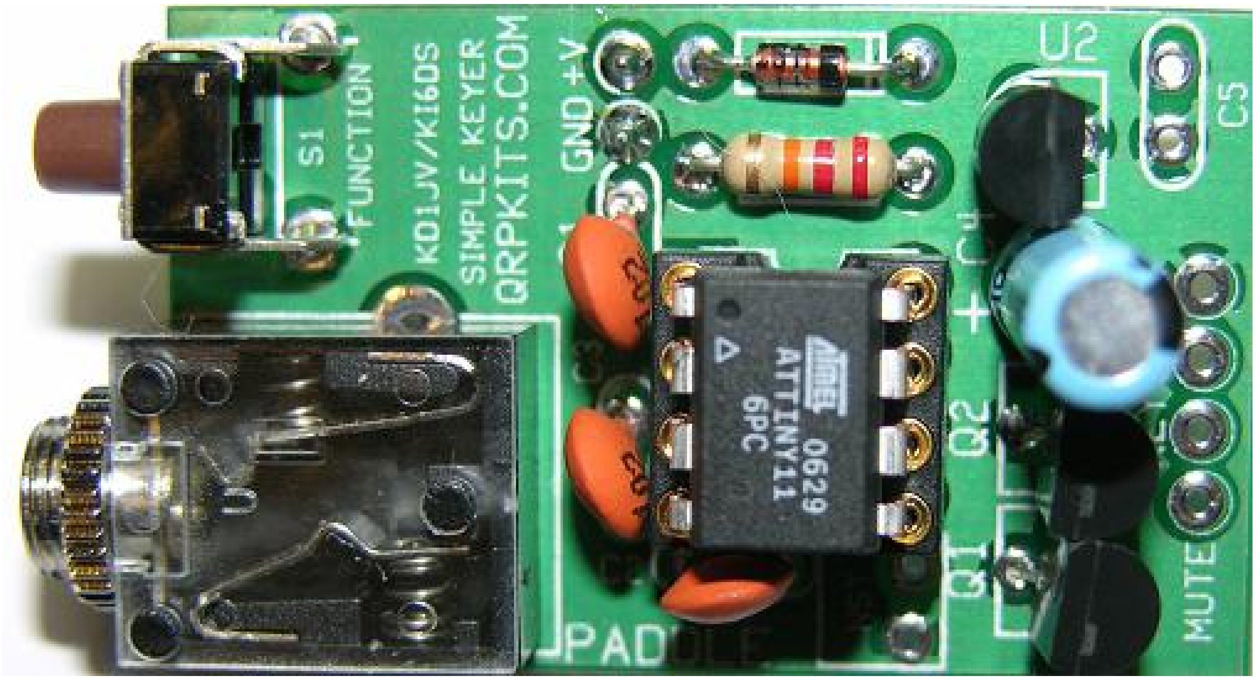
Pacific Antenna Return Policy

Pacific Antenna Simple Keyer Kit



Specifications and Features:

Speed range of 5 to 30 wpm

Operates in either iambic A or B mode, with B being the default

2 message memories

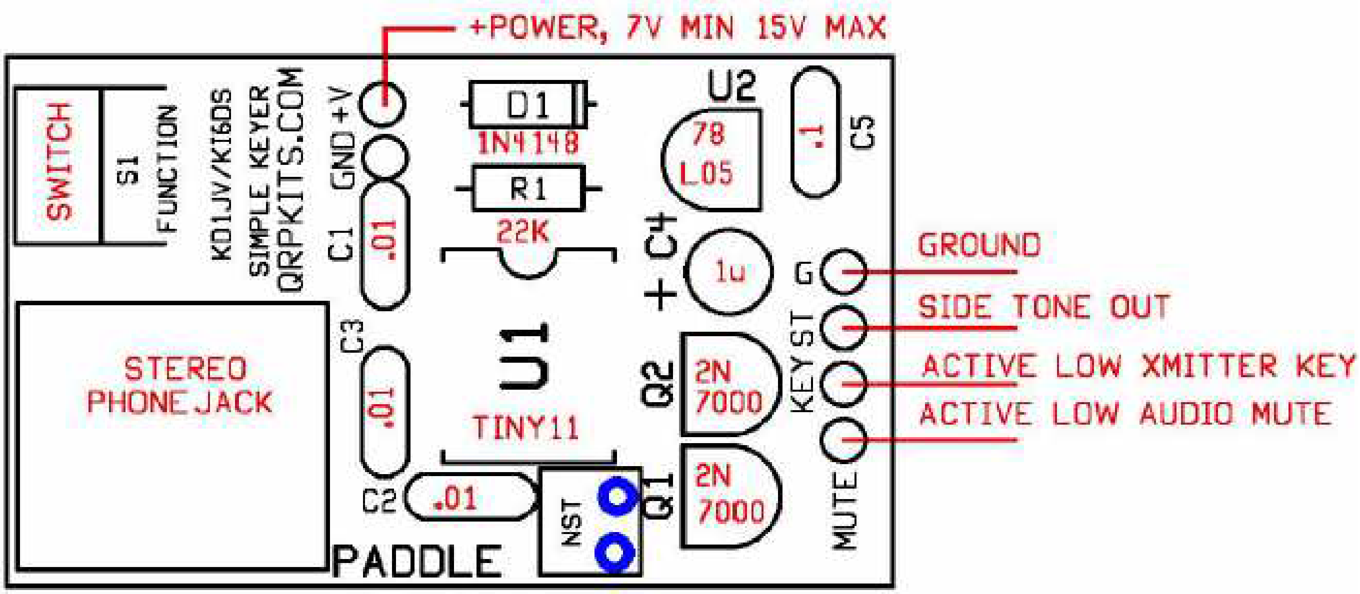
Tune and Beacon modes

Built on a 1 inch by 1.5 inch circuit board

Paddle jack can be used to mount the board or it can be remote mounted.

If panel mounted, only two holes needed

Parts Location Diagram:



Parts and Installation Sequence:

Install the following parts, making sure to check orientation with the diagram above and the board outline as they are installed

1) D1, 1N4148 glass diode, (match band end to board outline)
2) R1, 22K resistor Red/Red/Orange/Gold
3) 8 pin IC socket, (match to board outline)
4) C1, C2, C3 - .01uF (103) capacitor, (orientation does not matter)
5) Phone jack (only fits one way)
6) U2, 78L05 voltage regulator (match to board outline)
7) C4 – 1 uFd electrolyticcapacitor, (match board layout, + on board should be opposite – on capacitor
8) Q2, Q1 – 2N7000 MOSFET (match board layout)
9) C5 - .1 uFd (104) capacitor (orientation does not matter)
10) S1- Mode control switch, horizontal board mounted momentary switch.
11) Tiny13 microprocessor chip (match to board and socket notched end)

Connections:
The paddle jack is wired for "standard" paddle plug configuration of tip dot, ring dash, sleeve ground.

Key: This connects to the rigs straight key input and is active low.

Sidetone:
A Piezo electric speaker (not a buzzer!) can be directly connected to this output.
Note: A low impedance (8 - 32 ohm) dynamic speaker CAN NOT be directly connected.

If the keyer is built into a rig, the side tone can be injected into the rigs audio amp using a low pass filter to smooth out the square wave tone output to make it sound better and to reduce the amplitude from 5 volts peak to peak to something more reasonable. See the schematic on the last page for typical values.

If the rig uses a LM386, generally, one of the input pins is not used. This might be pin 2 or 3. Injecting the side tone (using the low pass filter) into the unused pin will produce volume control independent side tone level.

NST pads:
NST stands for No Side Tone. If your using the keyer with a rig which already generates side tone when transmitting, there is no need for the keyer to do it.

By putting a jumper between the NST pads, this will turn the side tone off when keying a rig. The side tone will still be active when the Function switch is used, as you need that audio feedback when using the switch.

Audio Mute output:
Most of the users of this keyer will not use the audio mute output. This output goes low (ground) before the key output does, and goes back high (open) about 7 milliseconds after the key output goes high (open).

The audio mute output is useful if you building the keyer into your own home brew rig, as it eliminates the R/C delay network normally required in the rigs audio mute circuit.

Using the NST jumper to turn the side tone off when keying will of course defeat the audio mute output. However, if your using the NST jumper, there is probably no need for the audio mute output.

Keyer operation:

The momentary switch is used to access the keyer functions.

Clicking and holding closed the switch for various lengths of time access these functions.

There are five possible functions which are selected using the "Function" Switch.

These are:

1. Send message

2. Set code speed

3. Enter and exit Tune Mode

4. Enter store message mode

Sending messages: (A message must be stored before this function will work)

After a short, quick click of the function switch, tap the Dot paddle to send message 1 or tap the Dash paddle to send message 2.

Once a message has started to be sent, it can be paused, stopped or set to beacon mode.
Note: only message 1 can be used for beacons.

Pause: Close and hold the Dash paddle.

Stop: Close and hold the Dot paddle.

NOTE: these actions will occur after a character currently being sent has finished sending.

Beacon mode:

Click and hold the function button as Message 1 is being sent.

The letter "B" will sound from the side tone when the mode is activated.

There is a fixed 3 second pause between repeating the message.

Closing either paddle during the pause will terminate beacon mode.

In addition, message Pause and Stop can be used during the sending of the message.

Change code speed:

A short, quick click of the switch enters change code speed mode.

There is a short pause to see if you want to send a message, then letter "S" will be sounded by the side tone.

Closing the Dash paddle will increase the code speed, a dot will sound incremented by 1 wpm increments

Closing the Dot paddle will decrease the code speed and a dot will sound each time the speed is decremented.

At the upper and lower speed limits, a double dot (I) will sound.

The change code speed mode will automatically exit after the paddles have been released for about 1 second.

Tune mode:

Tune mode is used when you want to key the transmitter continuously to say adjust an antenna tuner or make a power output measurement.

Click and hold closed the function switch until the letter "T" is sounded by the side tone (about 1 second)

To key the transmitter on, tap the Dash paddle closed.

To turn the transmitter off, tap the Dot paddle closed.

Repeat as needed.

To exit Tune mode and return to normal operation, click the Function switch.

Entering Messages:

Click and hold the function switch closed until the letter “M” is sounded by the side tone, about 1 second after the tune mode annunciation of “T”.

A message of up to 29 characters (including word spaces) may now be entered via the paddle.

If you exceed the maximum character limit, “EM” will sound and you will have to start again, making the message shorter.

If you have a 2X3 call, you won't be able to quite fit a 3x3 CQ into the memory.

“Ideal” timing of 7 dot times for character space and 21 dot times for word spacing is used to determine the completion of a character or word space.

To insure a word space in inserted, it is best to pause slightly longer they you would otherwise between words.

Click the Function switch when you are finished entering the message.

The message will repeat so you can check for timing errors. If you need to re-enter the message, click the Function button and “EM” will sound.

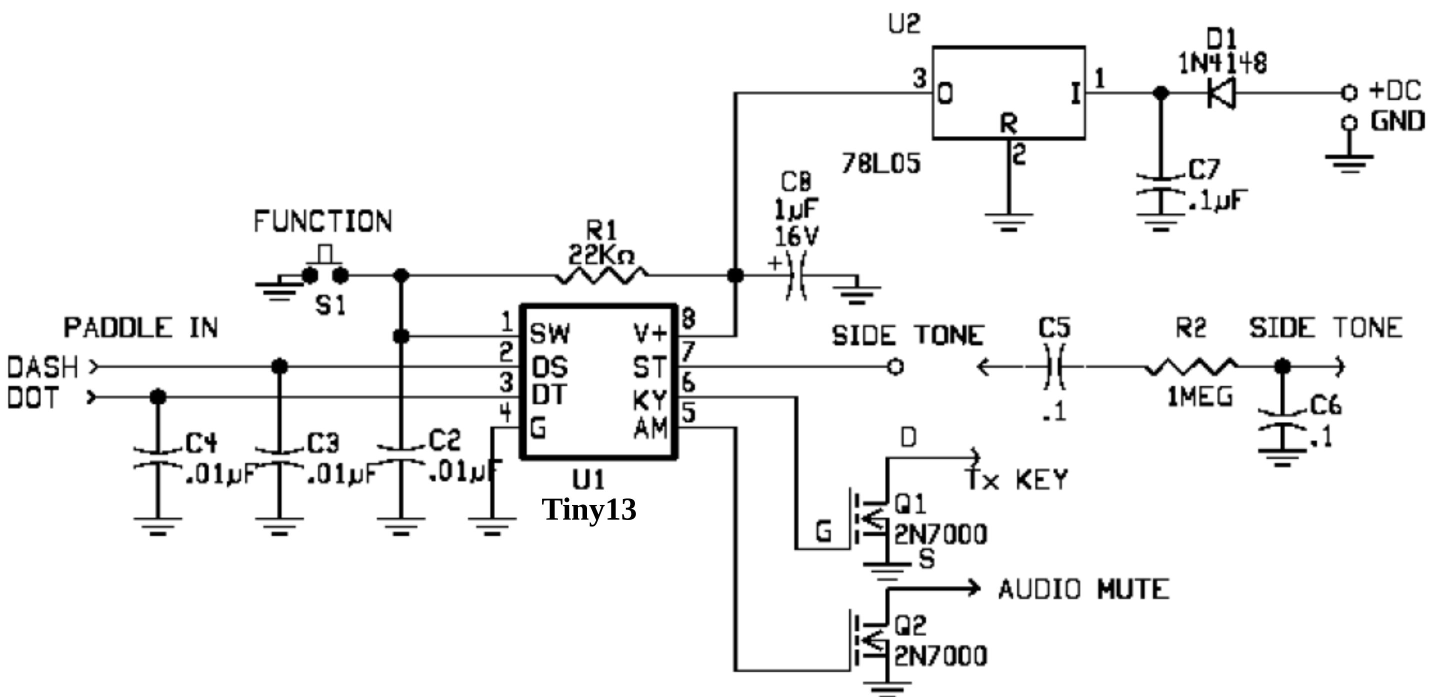
If the message was entered correctly, tap the Dot paddle to store the message in location 1 or the Dash paddle to store in location 2. “MS” (message stored) will sound and normal operation will resume.

Straight key mode:

If a mono plug is in the paddle jack at power up, the keyer will go into straight key mode.

In this mode, there is no need for the function switch, so it is disabled. This function allows using an external contest keyer if desired.

Schematic:

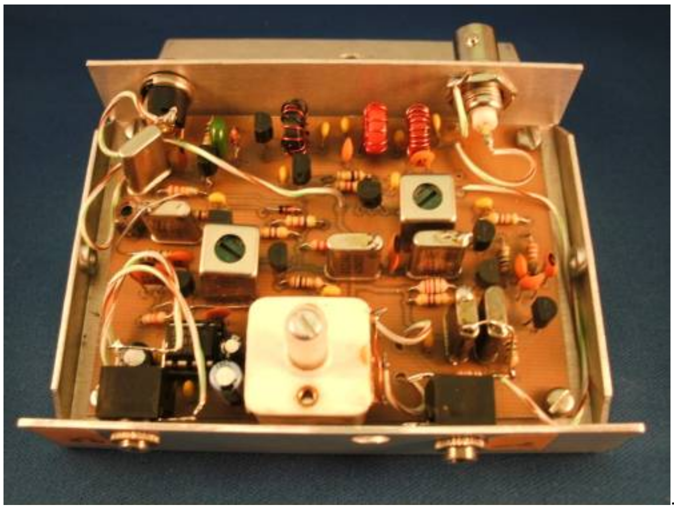


A CW transceiver for 30 Meters using 72 components

By KD1JV

For the spring 2010 FDIM (Four days in May) design contest, the ARCI (Amateur Radio Club International) decided on seeing if anyone could design a rig using 72 or less parts. What made this design a challenge was the fact the rig had to be a transceiver, the receiver had to have single signal reception and only 1 IC could be used. The design goal of my version was to come up with a reproducible design, using all common, easy to get and inexpensive parts. It also had to have a reasonably sensitive receiver and a transmitter with a bit more than flea power output. I meet these goals, the receiver having a MDS of about 0.5 uV - not great but usable - and a transmitter which puts out about 3/4 of a Watt. Nearly all the parts can be sourced from Mouser, the exception being the transmitter crystal and the toroid cores.

Five rigs were entered into the contest. I'm sorry to say my rig didn't win the contest (likely due to the receiver not working because of a lead shorting to the case I didn't notice after packaging it). I did however get an Honorable mention certificate.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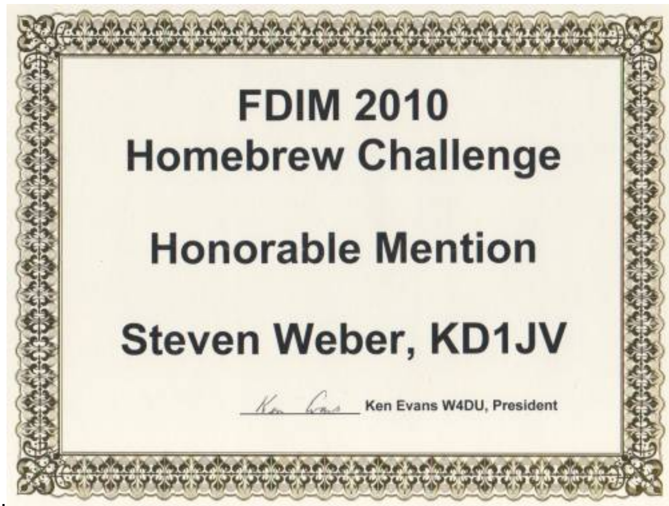


The Circuit:

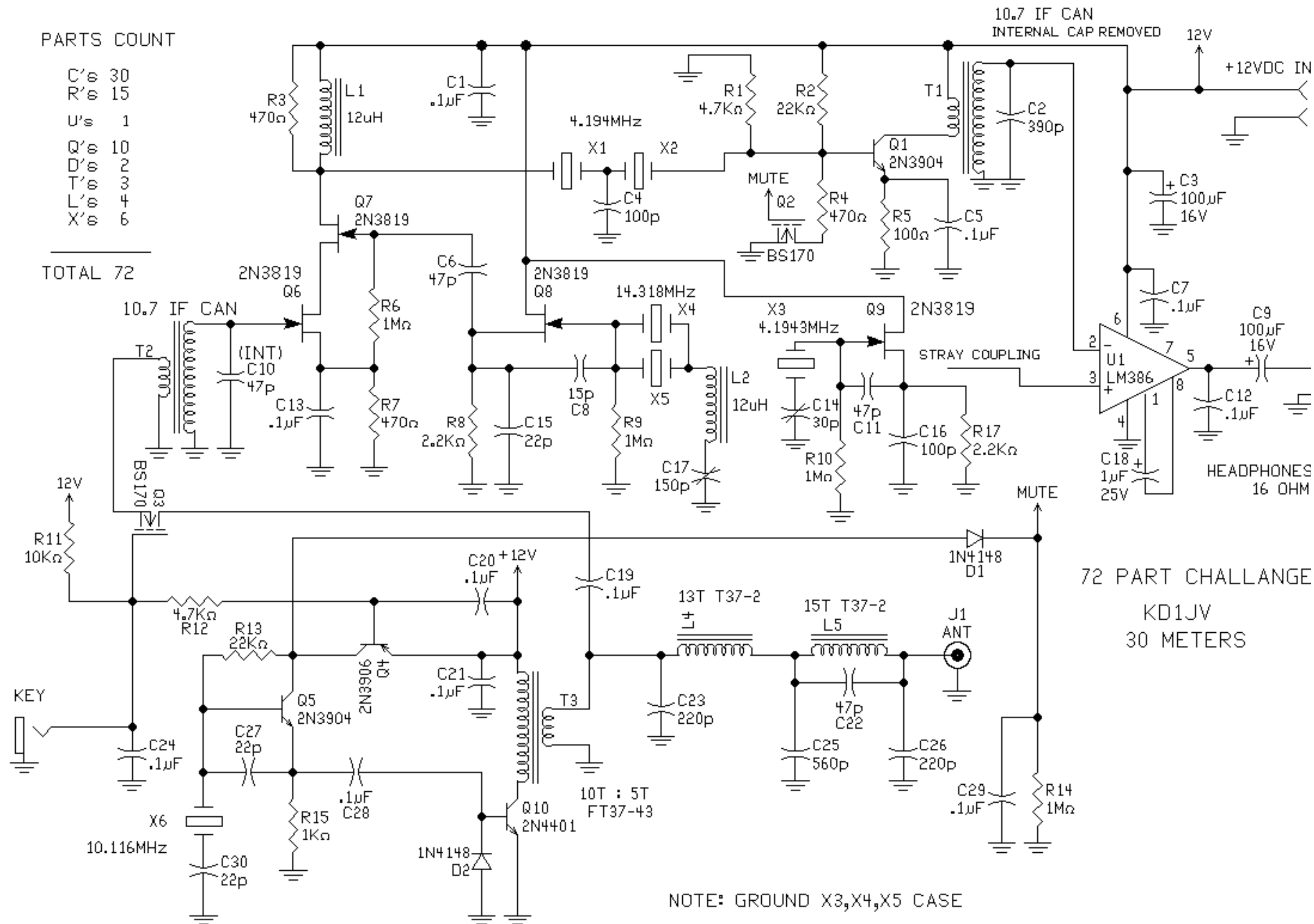
A number of different ideas for a receiver were tried before the final configuration was hit upon. It was quickly evident that making a rig with acceptable performance using only 72 parts was not going to be easy. I kept ending up with 80 to 90 parts. Everything finally came together after I hit upon the idea of using a LM386 as a combination product detector and audio amp. I'm not quite sure what made me think to try using a LM386 in such a fashion and was amazed when it actually worked! I'm not exactly sure how this works, but my theory is thus: If you look at the internal configuration of the LM386, you will see that the two input transistors share a common constant current sink. I believe the RF signals applied to the amplifier inputs are mixed in this current sink and the resulting audio beat note is amplified as if it were connected to one of the amplifier inputs. Some experimentation showed that the BFO signal had to be applied to non-inverting input pin 3 and had to be of very low amplitude. Therefore, pin 3 is left floating and stray coupling is used to inject the BFO signal. The amount of BFO injection is controlled by physically moving R17 closer or farther away from pin 3.

RF by-passing of the LM386 is important and must be done physically close to the chip. C18 across pins 1 and 8 improves the gain of the amplifier. MDS sensitivity of this product detector/audio amp is about 50 uV for a signal applied to the low impedance winding of T1.

The rest of the receiver is pretty standard. A super VXO provides pretty much full band tuning of 30M for the receiver. The mixer is comprised of series connected j-fets, which mimic a dual gate mosfet in operation. A simple two crystal, one cap IF filter provides reasonably good selectivity and opposite sideband suppression. An IF amplifier is required to get reasonably good sensitivity. Muting during transmit is achieved simply by using a MOSFET to switch a low value resistor to ground from the IF amplifier's base. This reduces the gain of the IF amp without completely turning it off. Side tone during transmit is achieved by tuning the receiver to the transmit frequency.

Because most of the 72 parts we were allowed to use are used up in the receiver, the transmitter had to be as simple as could be. This meant crystal control. Although directly keying the oscillator would have saved a few parts, using a PNP keying switch allows some wave shaping of the rise and fall time of the oscillator and simplifies controlling the QSK and mute switching. The single transistor output amplifier provides 700 mW of output power. The output

low pass filter attenuates all spurs to -50 dBc or better. This is achieved by adding C22 across L5, which makes a trap at the second harmonic.



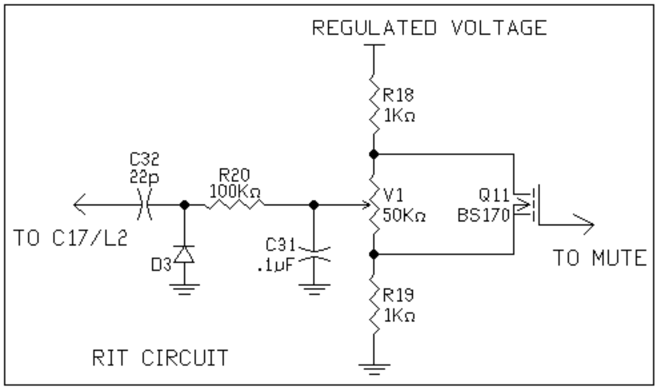
Improvements:

The schematic notes that the internal cap across the T1 secondary is removed and a 390 pfd cap used to tune the secondary to 4.194 MHz. This was done because if the internal cap was left in the IF can, it would have to have been counted as an individual part and that would have made the total 73 instead of 72. It really makes more sense to leave the cap in the IF transformer and use a 330 pfd cap to retune it instead.

2N7000's can be used instead of BS170's, but note that the Source and Drain pins are reversed between the two types. Therefore, when using 2N7000's, put them in the board 180 degrees from the part outline shown on the board.

Adding RIT would improve the usability of the rig significantly. This is easy enough to do and adds about 11 parts. Having RIT would allow keeping the receiver tuned to the transmit frequency to hear a side tone and allow tuning in another station which might not be exactly on your frequency. A suitable RIT circuit is shown below. The RIT voltage divider needs to be supplied with a regulated voltage. This could be either a zener diode and resistor or a three terminal regulator. A voltage of 8 to 9 volts would be suitable for the supply. The way this circuit works is during receive, Q11 is in an off state, allowing V1 to adjust the voltage across a tuning diode, D3. When the transmitter is keyed on, the mute voltage goes high and turns Q11 on, shorting out the RIT control, V1. The voltage across D3 is now centered at half the regulated voltage because R18 and R19 on either end of the RIT control are equal values.

No number is given for D3, as a number of different kinds of diodes will work, with varring degrees of tuning range. 1N4001 diodes will work, as will zeners with a reverse voltage of 20 or more volts. LED's also make good tuning diodes.



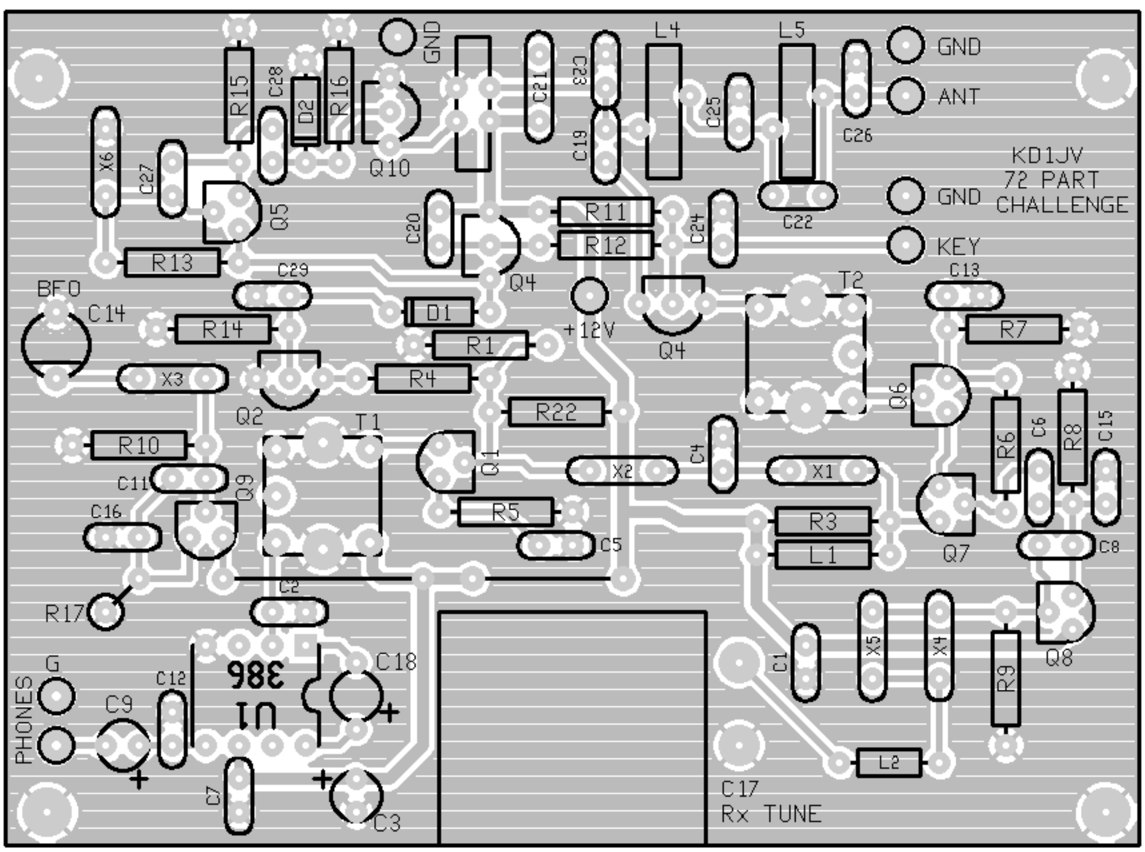
Construction:

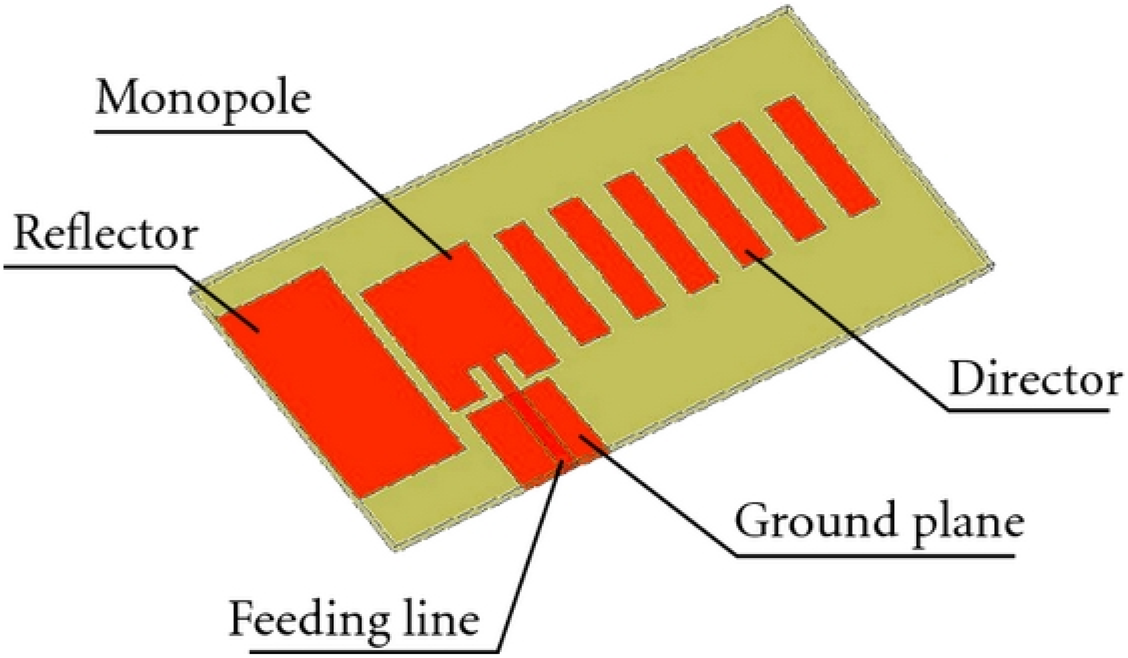
I built my rig on a pcb as shown. Dead bug on ground plane should work just as well. The tuning cap C17 is a polyvaricon, which can be taken out of a junk AM/FM radio or bought new from www.qrpkits.com. An air variable would work just a well (if not better, especially if it has a reduction drive built in) just being somewhat larger. A to scale board layout can be down loaded by [clicking here](). This is a through board view for directly printing on toner transfer film. The image gets reversed when you iron the print out onto the board.

Tune up:

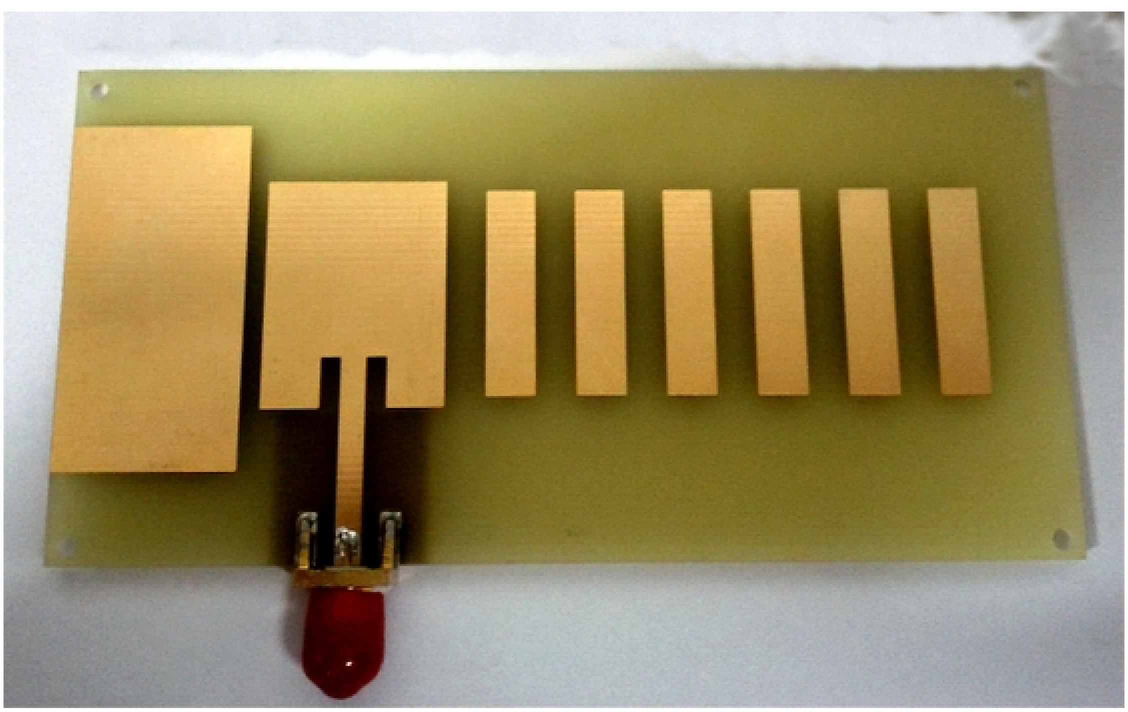
T1 and T2 will need to be adjusted for best receiver sensitivity. BFO trimmer C14 is adjusted for best opposite side band suppression. The position of R17 in respect to U1, the LM386 will affect receiver sensitivity. Tilt the resistor over towards U1 until a high pitch audio oscillation starts, then move the resistor away from the chip until the oscillation stops.

Parts layout: Actual size : 3.3" x 2.4"





(a) The structure of the quasi-Yagi antenna



(b) The photograph of the quasi-Yagi antenna

Figure 1: Compact broad-band quasi-Yagi antenna.

AMPLIFIER AND BIAS FOR THE CRYSTAL RECEIVER

(2003)

Amplifier and bias for the crystal receiver.

The LF amplifier
Much more stations can be received, louder and with a much better quality than with the crystal telephone. But it is intended for measurements and tuning purposes. When you cannot hear stations, it is impossible to adjust the antenna tuner.... With the amplifier, weak stations can already be heard when the antenna tuner is not set to maximum. Adjust the antenna tuner for maximum sensitivity and hope that you can also hear the station with the crystal telephone, without the LF amplifier.
The amplifier is also a nice extra option for comfortable listening with normal headphones to become familiar with the Medium Wave. Especially young people never have listened to the Medium Waves!
With the 20 meter long wire and after some experience, I do not need the LF amplifier for tuning adjustments anymore as there are always stations that can be heard with the crystal telephone. It is only used now for for comfortable listening with normal headphones and for measurement purposes.

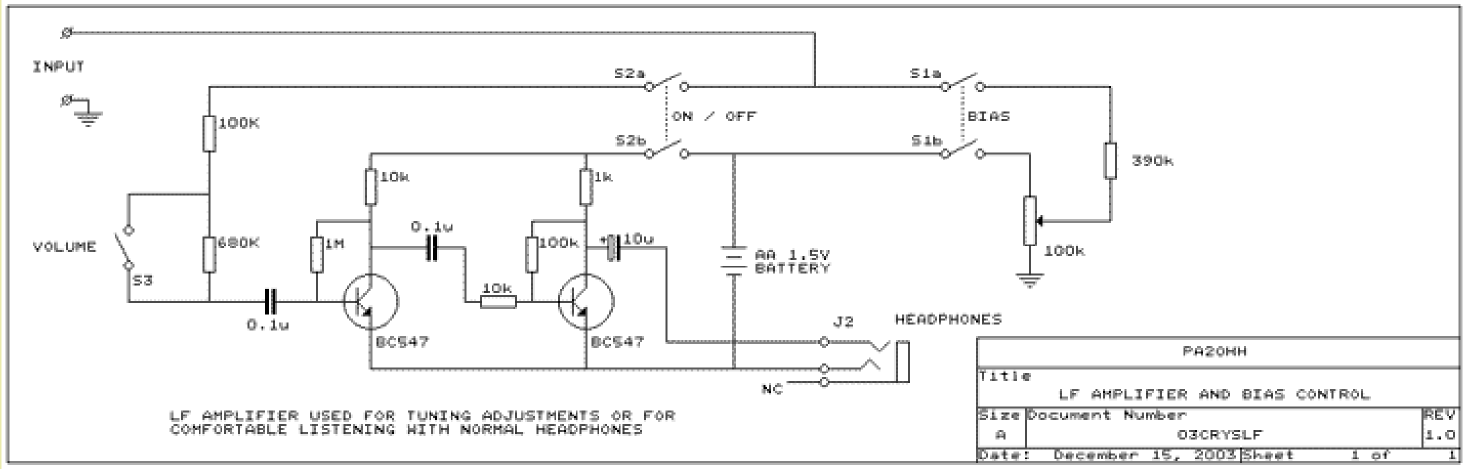


Diagram of the amplifier and bias control for the crystal receiver.

big diagram

Description

The gain of the LF amplifier is not very high, T1 is more an impedance matching circuit, gain is between 1.5 and 10x, depending on the position of S3, the simple volume control. In the low position, the high input impedance (680k resistor) hardly loads the detector.
Transistor T2 is the final amplifier and has a gain of 10x. The two earpieces of the headphones are connected in series instead of in parallel for extra audio output.
Battery life: 1 mA current, one AA cell is good for 2000 hours of use.
The bias circuit is switched on with S1 and the bias voltage is controlled by the 100 k potentiometer.

Inside view

Bias voltage control

The purpose of the bias voltage is to decrease the negative effect of the turn on voltage of the diode.
The effect of the bias voltage is rather unpredictable, sometimes it has a positive, sometimes a negative effect on the sensitivity of the receiver. It depends on the tap/top switch, frequency range etc. My general experience is that the positive effect is negligible in most situations, you can do without it. But sometimes it had a positive effect on the reception of weak stations and the audio quality of strong stations. Mostly there was a positive effect when the diode of the receiver was on the tap position and a negative effect when on the top position.

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Simple Receiver

Specifications

As measured from current prototypes, some variance in performance is expected from unit to unit.

- Receiver Type: Superhet with a three crystal IF filter Receiver sensitivity: Better than -120 dBm
- Current Drain: ~ 17 mA at 12v.
  Features:
  - Bus switch first mixer improves handling of high level signal (40m SWBC!)
  - AGC - Automatically reduces large signals
  - 3 pole Crystal filter
    - Single sided receiver reception
    - Wider 500 Hz filter decreases "ringing" and listener fatigue
  - Audio gain chain incorporates active R/C low pass filter
    - Reduces unwanted high frequency audio gain stage hiss
    - Provides >30 dB additional attenuation for signals more than 2KHz away

- Headphone level output with diode limiting - o Protects your ears from static crashes or sudden strong stations
- Band coverage provided in two ranges
  - Each tuning range ~ 20 KHz wide
  - On board switch selects upper or lower band segments
    - 40m covers 7.000 to 7.022 and 7.024 to 7.049 MHz (DX and QRP segments)
    - 30m covers 10.100 to 10.120 MHz
- External "mute" input (active low)
  - Reduces receiver gain by ~ 70 dB
  - Receiver input protected to 5w when muted (only when muted!)

Manuals and other useful information

[Simple Receiver (SRX) Construction Manual (05/05/2013)](#)

Ordering Information

To order this kit, use the buttons below. (you do not have to have a PayPal account to pay for items using a credit card)

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Use Add to cart buttons to add an item to your shopping cart. Use "Continue Shopping" tab to go back and add multiple items to your cart. You can view shipping charges before making payment. Payment can be made by Credit Card, Debit Card or by Paypal. Selecting "Checkout" in your shopping cart will allow you to use a credit card rather than Paypal Please be sure the address you supply is correct. We receive an automated notification when you complete payment. Your order will be shipped as soon as possible unless otherwise stated. Thanks for your support!

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Pacific Antenna Return Policy

Projects

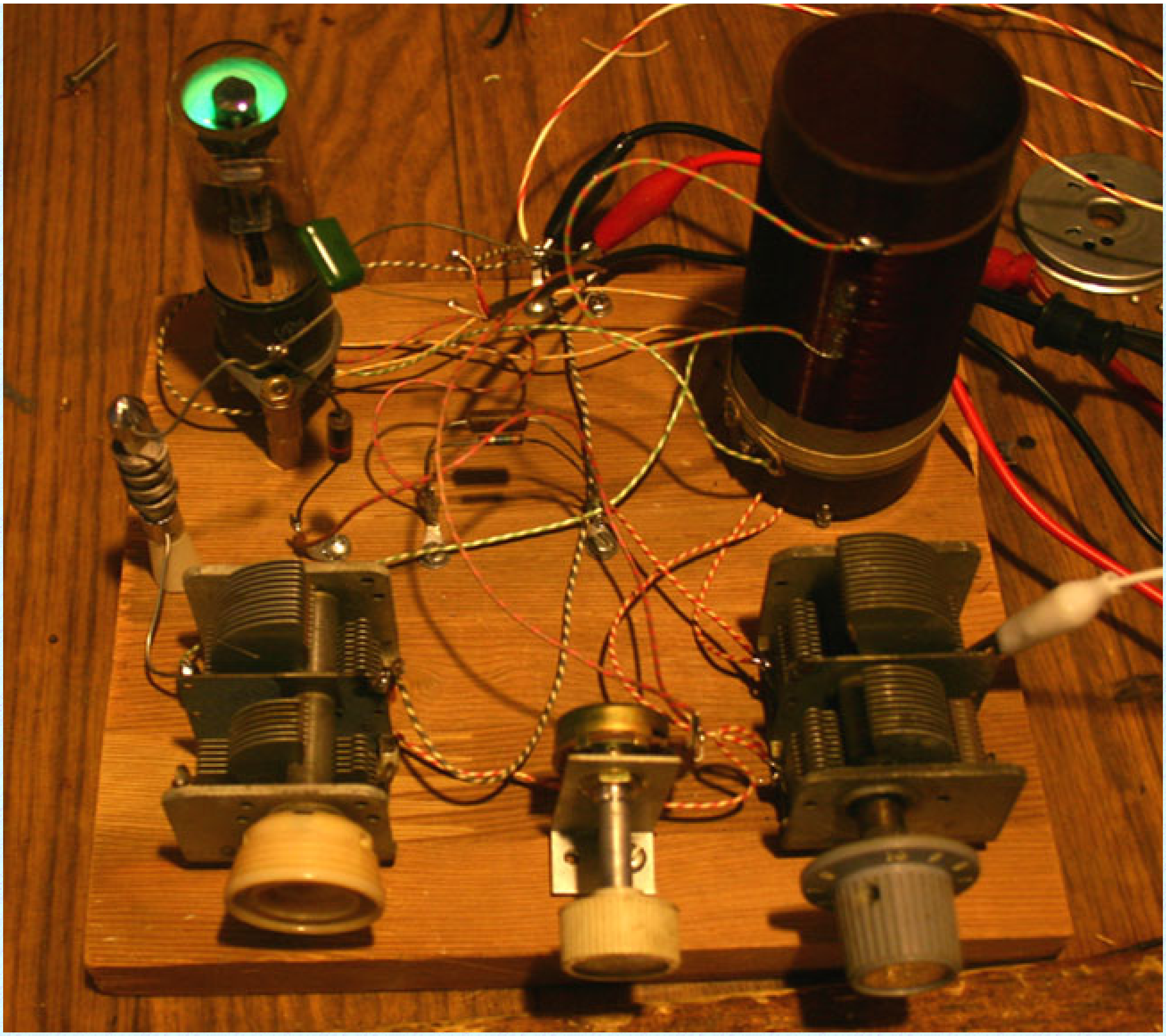
A one tube radio receiver using a magic eye tube

I was recently asked by a reader and amateur radio operator from Brazil if I had a circuit for a one tube receiver using a magic eye tube. I did find such an article online called "Build the Cyclops" which seemed to be exactly what he was looking for.

Being naturally curious and also feeling like this is something I ought to look into, I began to do some further reading about regenerative sets and I began to gather parts for the project. I found a couple of old tuning capacitors, a coil from an old TRF set, and the miscellaneous other parts needed. After finding a suitable piece of scrap wood, I began to build my prototype using a readily available 1629 magic eye tube, a 15 megohm grid leak resistor in parallel with a 100 picofarad capacitor. I put the set together rather hastily and did not pay too much attention to details figuring that I can always do a better job later.

After some experimenting, I found that I had to reverse the wires to the "tickler coil" and tap my tuner coil to receive stations on the high end of the broadcast band. An anode voltage of 135 volts and a plate resistor of 270 kilohms seemed to work optimally.

My expectations were not very high, but I was very happy with the performance of my set and really had fun working with it and trying to tune in various stations. The movement of the eye is not as pronounced as on a superheterodyne set, but it is noticeable and varies with audio strength as well.

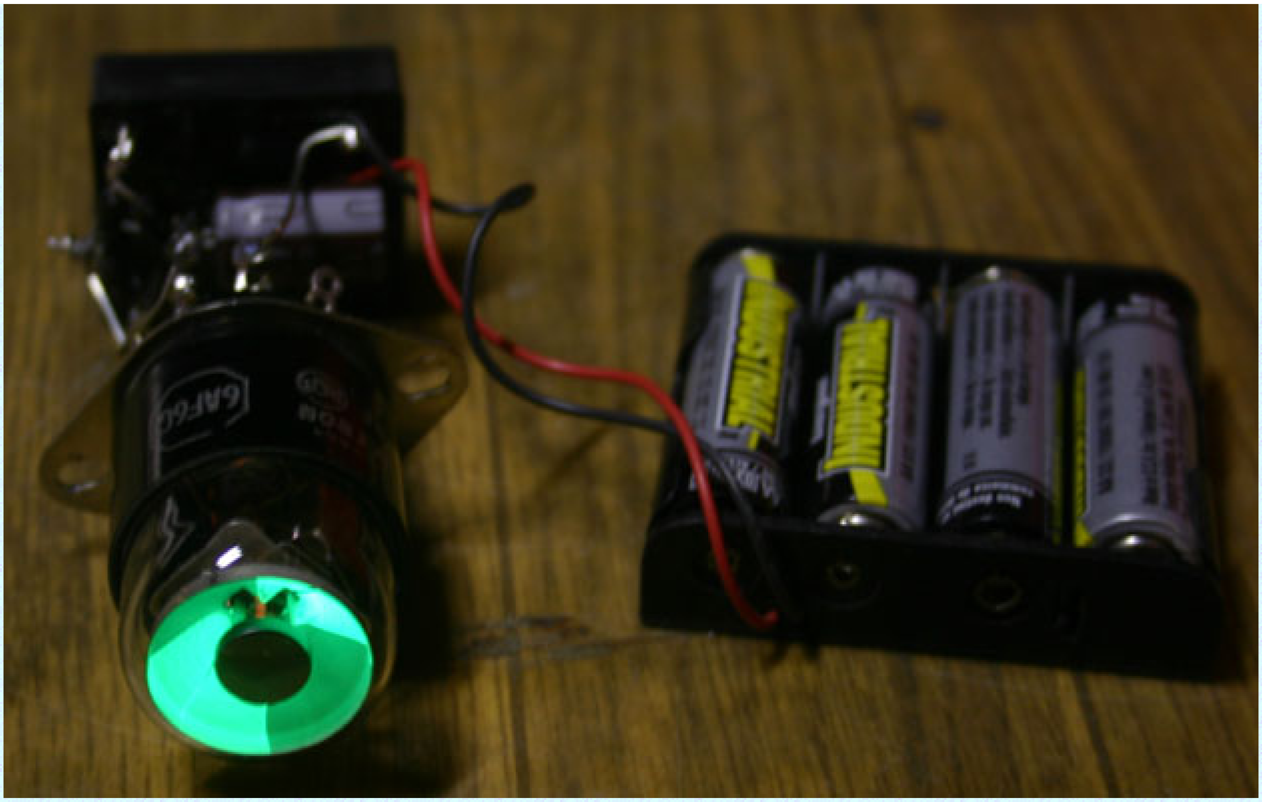


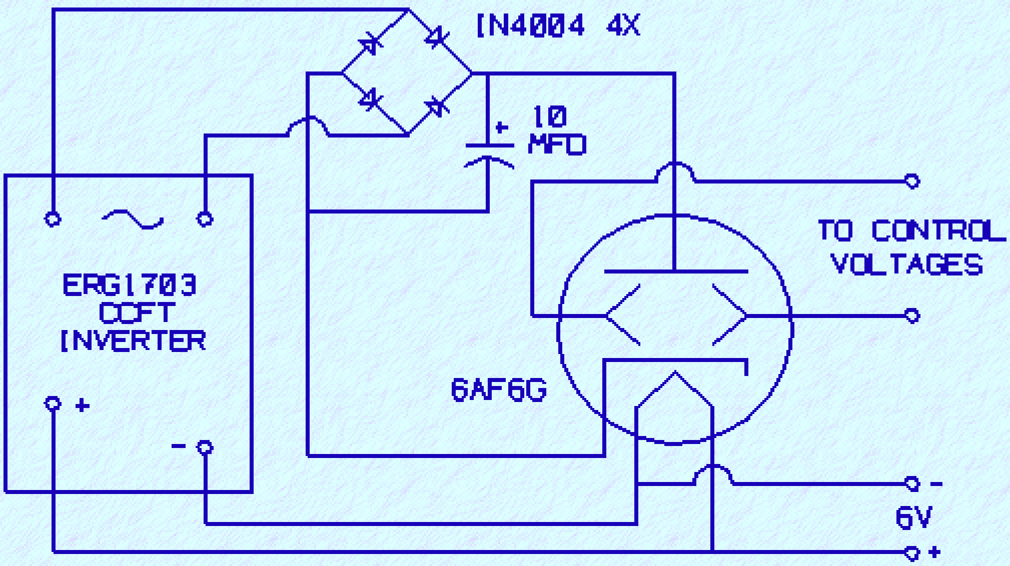
I expect to experiment more with this set, trying different types of magic eye tubes, probably types like the EFM1 or EFM11. I also want to experiment with the antenna and try to wind some coils myself in an effort to receive some shortwave stations, and lastly I will find or build a suitable enclosure.

- March 2008

Magic eye tube on battery power

A reader recently sent me an email asking me if a magic eye tube could be powered by a 6 or 9 volt battery. I thought about it for a while, trying to figure out the most practical way to obtain the high voltage needed for the target. Instead of designing a specific power inverter circuit, I resorted to checking my junk box (actually my junk basement) and found a box full of CCFT inverter blocks I had salvaged from some POS terminals. I was unable to find any statistical data on them, but by experimenting I was able to make the magic eye tube light up with a minimal amount of external components.





After assembling my prototype circuit, the magic eye tube ran successfully for eight hours drawing about 190 milliamps. Above is the schematic for my circuit, which I hope will open the door for many other creative opportunities for use of the magic eye tube.

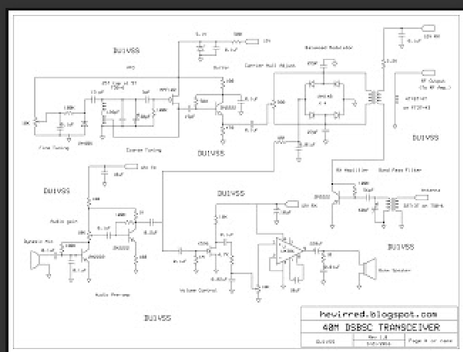
- May 2008

du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Sunday, March 20, 2016

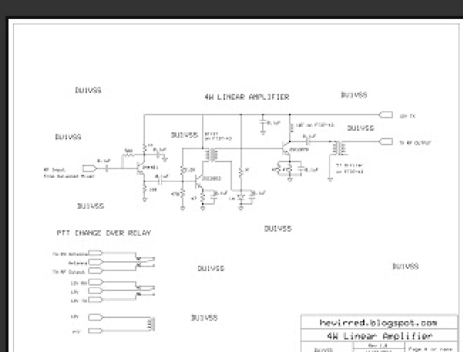
40M DSB Transceiver



The circuit described here is actually a modification of the MDT40 project by VK2DOB, A simple double side band suppressed carrier (DSBSC) transceiver which operates on 7MHz. I find this project simple and a good start if you are interested into home brewing your own rig so I decided to make one.

On his original circuit, it uses a ceramic resonator as a common oscillator for both receiver and transmitter stage, but I find it difficult to find here in Manila. I decided to use a vfo whose circuit was copied from KD7REM, a rocksteady vfo. Stability is considerable during start up which usually takes less than 30minutes of wam-up and can be used with a couple of QSO without correcting the vfo for a drift. T50-6 toroid was chosen as a core of my inductor where 25 turns of enamel wire was wound. RF feedback was taken at 5 turns from the cold end. I found by experiment that by keeping the capacitance large in the L/C ratio, the oscillator is more stable than the other way around. MPF102 is also used since JFET is more stable than its BJT counterpart.

The balanced modulator and the receiver pre-amplifier stage are constructed together in one board. There are four 1N4148 used in the balance modulator and please note that these diodes are carefully matched by their forward bias voltage. A 500 ohm potentiometer is used to find the null in the balance modulator. Carrier suppression is easily done when you already have completed the transmitter stage since this can be just adjusted by the power output of the rf amplifier stage.



The rf transistors found in the transmitter stage are uncommon so I decided to redesign completely the entire stage using common transistors that are locally available here. 2SC2078 was chosen as the final stage since it is cheap and offers a 4W to 5W ouput at the HF frequencies.

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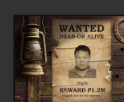

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Ham since 2000.

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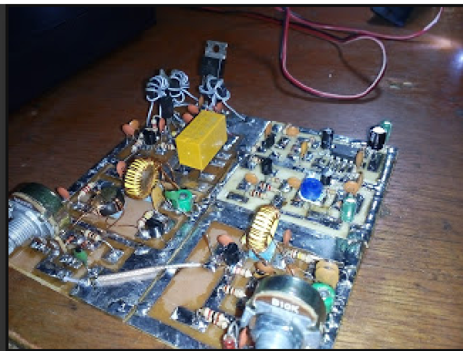

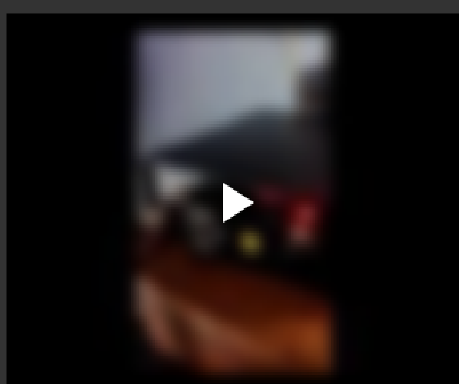

Above is the prototype of my DSBSC transceiver that I made. It is housed in a plastic casing (black) and on the top (grey plastic casing) is the additional 15watts linear amplifier constructed using a push-pull IRF510 mosfet transistor. ---73 de du1vss

Posted by hevirred at 9:42 PM

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Sound-Powered Telephone Spotter's Guide

Here are a few of the commonly seen sound-powered telephones that are useful for crystal set purposes. Elements generally have a nominal impedance of 600 ohms. Wire in parallel for 300 ohms or in series for 1200 ohms. You'll need a transformer that matches this low impedance to 10K ohms or more. 100K is very desirable.

Field Testing: If you put one of these to your ear, you'll be able to hear yourself. If you're not sure, short the input lead, which will kill the signal. This does not apply to the TA-1/PT. The push to talk switch disconnects the receiver in this phone.

US Navy "Deck Talker": Actual nomenclature is unknown. The frame detail around the earpiece is a dead giveaway. These are highly desirable as they already have a headband and two earpieces. You'll most likely want to disconnect the breast plate and microphone. Install the mic element in your antique horn speaker for improved performance.

US Army Signal Corps Handset TS-10: These were made by many different manufacturers. Some use the same element for both transmitter and receiver. This means you can make a headset from a single TS-10. Others use dissimilar elements. The transmitters are usable as receivers, so don't throw them away. However, it's best to have a matched pair. The rounded shroud over the mouthpiece will help you identify these at a distance, but some none-sound-powered phones have a similar configuration. Some examples include a push-to-talk switch.

Telephone Set TA-1/PT: This is an entire magneto type field phone built into a handset. The transmitter and receiver elements are dissimilar. The elements are less sensitive than the others shown above, but still better than common headphones. The elements are small enough to fit inside Baldwin Type-C cases. These phones tend to sell for about $30 so they're not such a great deal. Receiver elements are labeled TA-118/PT. You may find some in miiltary surplus channels.

HOME

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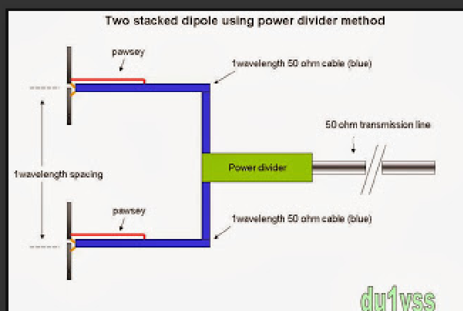
Saturday, November 9, 2013

Two Stack Dipole Using Power Divider



My friend ask me If I can make a two stack dipole for his 92.9MHz FM station and I decided to construct this project using a home made coaxial power divider using a two piece quarter-wave long 75 ohm coaxial cable. The two 75 ohm coax was connected in parallel to obtain 37.5 ohm which is the required impedance for our power divider. I also use a 1 wavelength long 50 ohm coax feeding the two dipoles and along with it, a short piece of wire that act as a pawsey stub that makes the dipole feed point balance. The 1 wavelength long 50 ohm coax was also chosen so that each dipole can be vertically spaced at 1 wavelength for gain optimization.

A plastic element insulator hold the dipole segments on a 1"x1" square tube boom. The feed point connection was carefully protected with a layer of rubber tape and on top of it is an electrical tape for UV and water protection.

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► 2017 (3)
► 2016 (3)
► 2015 (4)
► 2014 (6)
▼ 2013 (4)
▼ November (1)
Two Stack Dipole Using Power Divider
► July (2)
► June (1)
► 2012 (4)
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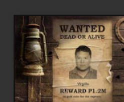

hevirred

Ham since 2000.

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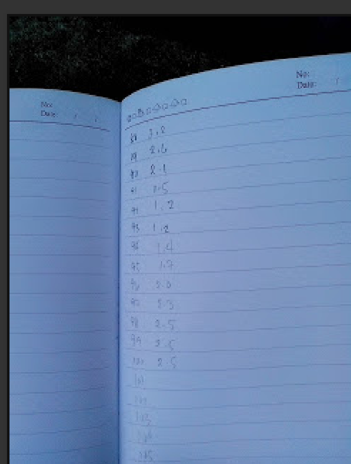
A fabricated bracket will hold the antenna boom and this was made of a thick plastic material, the one used here was a chopping board 5mm in thick.

A close up view of the coaxial power divider during initial tuning and testing.



A quick frequency sweep was made to evaluate the antenna SWR after the trimming of dipole segments. The antenna bandwidth was quite narrow for this design and I was able to obtain an SWR value of 1:1.2 across 92MHz to 93MHz only.

During testing, the two dipoles were spaced 1 wavelength horizontally and was 1 meter above the ground just only to evaluate the SWR and tune the antenna while at the ground. When installed permanently, this antenna is expected to yield 3dBd of gain theoretically. 73 de du1vss

Posted by hevirred at 3:15 PM

G+

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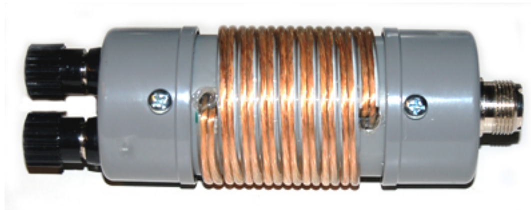
Netherlands, January 14, 2018

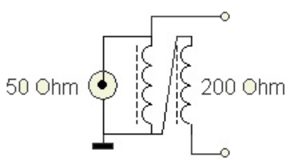
A 4:1 Air-wound Balun



Since some time I have been using the Diamond CP6 multiband vertical for my HF activities. While this antenna performs well on 6m, 10m, 15m and 20m and also does a reasonable job (for it's length) on 40m, it does not work at all - for me anyway - on 30m and 17m. The latter is one of my more favourite bands to listen on, so it was time to do something about it. Even though my LDG AT-100Pro automatic tuner keeps the IC-7000 happy while transmitting on 17m, the signal does not really get out and reception is poor.

My home has an attic and that was big enough to string some wire up. I decided to have a play around with a 17m long deltaloop fed with openwire feeder. The feeder was salvaged of an old G5RV given to me by a friend (thanks Hennie). Theoretical calculations show the impedance of a deltaloop cut at its fundamental frequency to be 150 Ohms when fed from the side. So using this setup, I was in need of a 4:1 balun to present the AT-100Pro with a more reasonable load and at the same time transform the balanced line back to unbalanced.

Definition : *A balun is a device that joins a balanced line (one that has two conductors, with equal currents in opposite directions, such as a twisted pair cable) to an unbalanced line (one that has just one conductor and a ground, such as a coaxial cable). A balun is a type of transformer: it's used to convert an unbalanced signal to a balanced one or vice versa. Baluns isolate a transmission line and provide a balanced output.*



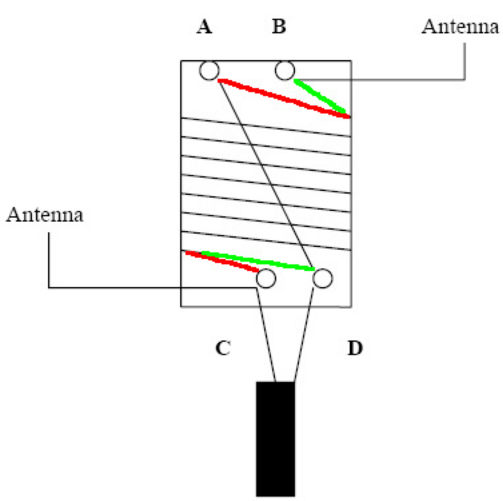
Quite often toroids are used to make baluns with. Even a ferrite rod from an old AM radio can be used. I however have something against using ferrite materials in baluns. If you are not carefull, the ferrite can get saturated and heat up. You won't be the first blowing up a balun when using QRO. So instead of ferrite, I went with an air-wound balun.

Documentation | Projects | Information | Links | Downloads | Home

This air-core balun is wound using the following components :

- 40mm diameter grey PVC pipe with a length of 9.5cm
- 2 endcaps 40mm PVC
- Simple zip cord (multi-stranded core insulated wire)
- 8 turns bifilar wound
- 2 banana type chassis connectors
- 1 SO239 socket

When fed with the 50 Ohm coax from the AT-100, the balun transforms this impedance to 200 Ohms which is close to matching 150 Ohms. The image below shows how to wire the balun :



Terminals B and C are wired to the banana chassis connectors for hooking up the feedline. The SO239 terminal center pin is wired to C and it's shield to D. Make sure to connect D and A together. As can be seen on the image at the top of this page, the wiring enters the PVC pipe and all connections are made internally. In my case - since I am using the balun inside - I did not glue the endcaps to the pipe but used a couple little screws instead. This way the balun is easy to service should the need arise.

Good luck constructing yours !

Two Wireless Detectors

A month or two after I made my presentation to the New Jersey Antique Radio Club on mounting mineral crystals for detectors, Marv Beeferman ask if I'd examine two detectors that he had obtained in a box lot at the Henry Ford Museum auction last year. He handed me two brass cylinders about an inch and a half in diameter. Each had a hard rubber base with two brass pins.

When Marv first obtained these devices, the brass covers were tightly jammed on the bases, making it impossible to identify their function. I'm sure if any half-way-knowledgeable radio historian had seen the insides, they would not have been in a box of effluvia. When Marv carefully opened the cases, he found two marviously constructed crystal detectors, neither of which involved the usual galena and catswhisker.

The first detector contained a small piece of rock, showing the unmistakable red-orange color of zincite (zinc oxide), in contact with a second mineral sample. This is the classic perikon detector. The second mineral is probably Bornite, Cu_5FeS_4, but it's hard to make a positive identification without damaging the specimen. By the way, zincite is a rare mineral except in the Franklin area of Northern New Jersey. (Local interest.)

The second detector consisted of a piece of layered lead-grey material, held in a carefully machined clamp, in contact with a hairpin-shaped flat metallic spring. After consulting several

vintage radio books and *A Field Guide to Rocks and Minerals* by Frederick H. Pough, I identified the mineral as Molybdenite, MoS_2, an early favorite of the Telefunken Company.

I carefully cleaned the contact surfaces of both detectors with isopropyl alcohol and tried them in my laboratory reference crystal set.

The perikon detector showed a very weak signal from local powerhouse WOR. Tightening down on the thumb screw improved things. Tightening some more, resulted in still louder reception. All in all, its performance was about what I had expected from my reading: ok, but not nearly as sensitive as Galena or a modern germanium diode. As a rough comparison, I'd say it works about as well as a silicon diode.

The "moly" detector just barely worked, despite repeated adjustment of the contact. The application of a little DC bias to the detector, provided by a potentiometer across a pen-light battery, brought the ancient semiconductor to life. Performance was about on par with the perikon unit.

Detectors of these kinds were used in commercial applications because of their ruggedness. A galena detector requires a very delicate touch from the catswhisker, making it a poor choice for use on a vibrating ship in rough waters. Also the rectifying junction of a galena detector can be easily destroyed by a distant lightening strike or RF from the transmitter.

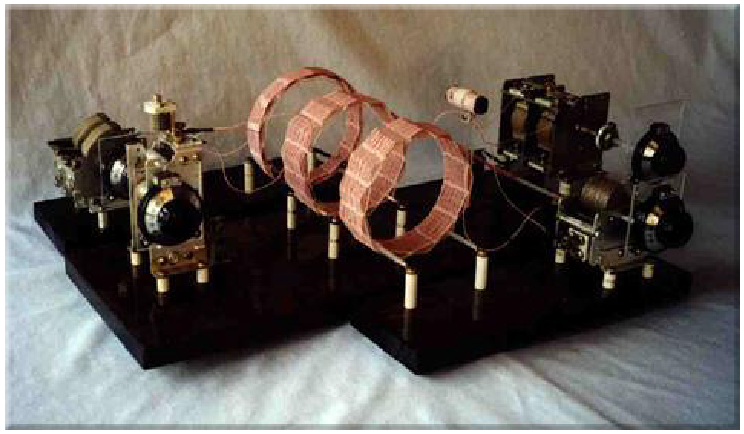
Because of the materials and construction style employed, I'm guessing these detectors were built during the wireless era for commercial or experimental application. They were probably made in the United States, as the screw threads are standard SAE types.

If any of our readers have further information on these units, Marv and I would like to hear from you.

Return to SkyWaves Home Page

lyonodyne

Lyonodyne



Builder and Operator Mike Tuggle

The "Lyonodyne-17" is an advanced DX crystal set evolving over the years. It was a first place winner of the DX "Open Class"contest two years in a row in 2000 and 2001. Mike placed second in 2003 after handicapping himself by using a rock (lead telluride) as the detectors. The radio incorporates the "Tuggle" front end (which will be shown later), and very high quality parts.

Note:

This is not intended as a "How To" article for a beginner. The following is supplied as information only. Some of the techniques used in the construction of this radio are very advanced and not recommended for a beginner or even an intermediate builder.

The following is from Mike Tuggle

Lyonodyne Version 17 Crystal Set

Summary

The "Lyonodyne-17" is a much-advanced version in a series of DX crystal sets evolving from circa 1974. I've been particularly interested in crystal sets since 1959, when I first discovered you could actually DX with them. It's a completely passive set -- no amps, no bias on the detector. The circuit is double-tuned and uses super-high quality components: silver-plated variable capacitors and high-Q litz wire basket-wound coils. Isolated coil Qs are in the 700s across the BCB and over 1000 for much of the BCB. In-set Qs are less, of course. Phones are high quality, surplus sound powered ("balanced armature") units, matched to the high-Z secondary tank/detector by a high quality line transformer. Detector is a single 12101 3RT, sold by Radio Shack as a "1N34 Type." It's the best I've found so far. With traps and all, it takes up the better part of a desk top.

Description

After several abject experimental failures, I concluded that the magical "high L-to-C ratio" for tuned circuits is a crock -- in spite of what theory might suggest. That, and the high Qs obtained in 200/44 litz wire (now, 660/46) coils got me to re-thinking my set's design and construction. This led to a completely rebuilt crystal set -- same circuit, but redesigned components per the following principles:

(1) design for the lowest L/C ratio as practical

(2) use highest quality variable capacitors available

(3) if necessary, pad the variable capacitors with high-quality air trimmers to get to lowest frequency and spread out top-end tuning

(4) choose coil design which peaks in Q in the central BCB range -- operating near the self-resonant frequency is self-defeating

Superior quality tuning capacitors (silver plated with ceramic standoffs) were used in the present version. The two prime tuning capacitor candidates I had were a 500 pF and a dual, 470 pF per gang, both silver-plate, ceramic insulated. (Typical parallel leakage resistance measurements on these were 20 megohms, by the Boonton 260-A.) Accordingly, the set was designed about them.

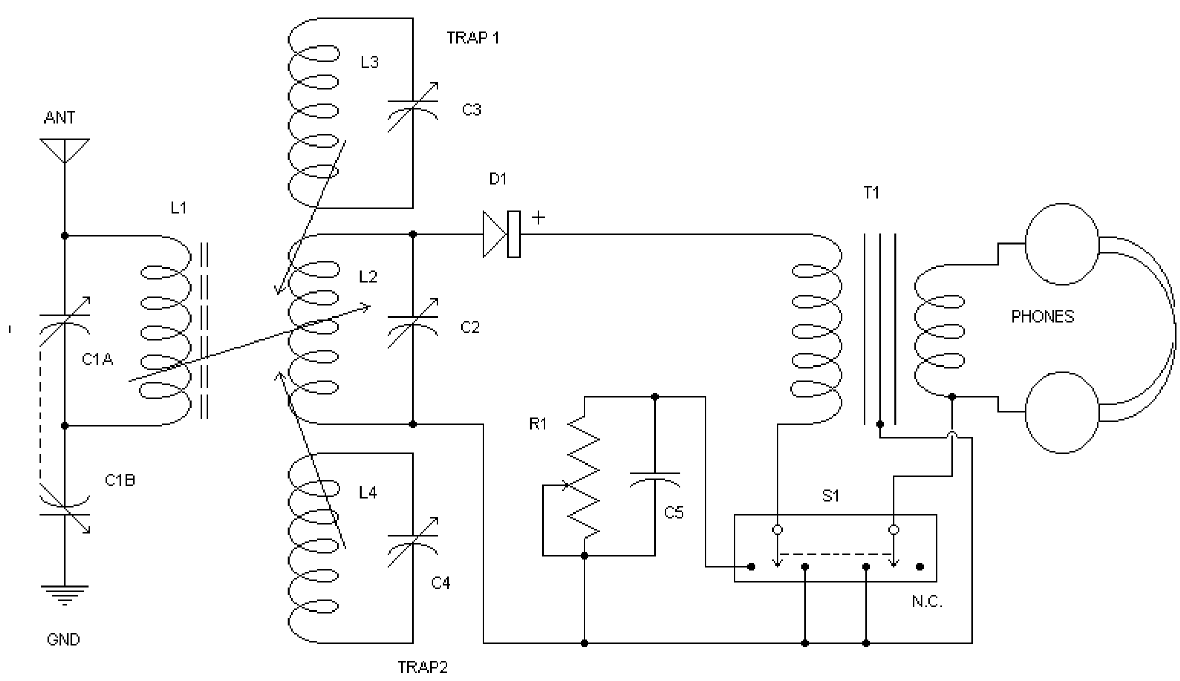
I credit Bill Bowers of Oklahoma with exposing me to the virtues of finer-strand litz for medium frequencies, the use of larger coil diameter-to-length ratios (ca. 5-to-1) than theory suggests, and for going back to 'over-1, under-1' winding pattern. They are not as pretty and have lower L's than the same-sized 'over-2, under-1's', which I used for many years, but they do have substantially higher Q's.

And credit to Al Klase for preaching the virtues of sound-powered phones long enough and loud enough that I finally had to listen -- despite my being firmly convinced nothing could ever surpass Brush crystal phones. The sound-powered's are a real ear-opener, literally, and an order-of-magnitude improvement.

Antenna has been, for some time, a 50-foot, 4-wire flat top (wires spaced 1 ft. apart), maybe 25 feet high. At my previous location, I used to have a 105-ft. long-wire, but high winds took out the tree at the other end. The shorter flat top worked so well I brought it here to Hawaii, where real estate for long antennas is at a premium. It's about all I can fit gracefully onto this lot. Ground is tapped directly into the city water system.

Circuit Details

The antenna-ground system is tuned by the primary, L1-C1, and is coupled to the secondary, L2-C2, via loose L1 - L2 coupling (physical distance 3 to 4"). L1 and L2 are positioned radially (side-to-side), while the coils of two QRM traps (high-Q, parallel L-C ckts.) are coupled axially to L2. L1 has virtually no effect on L2-C2 tuning and Q, but the QRM traps do affect tuning, especially near the QRM frequencies. So, their coupling is kept to the minimum which will still allow reception of the stations of interest. The set is capable of receiving stations on frequencies adjacent to murderous locals. The low-Z sound-powered phones are impedance-matched to the secondary tank , L2-C2, and detector with a UTC A-27 100 k-ohm-to-200 ohm input transformer. The single12101 diode detector is estimated to present about 200 k-ohm resistance in the forward direction. These impedances, in series, allow you to place the detector-phones directly across the tuned circuit without undue loading. Taps, used in the past, are a mess -- especially with litz wire. Further, they kill a coil's Q, and are to be avoided if at all possible.



Lyonodyne-17 Parts (as of 2/5/01)

C1 two gang, 15-470 pF per gang, variable capacitor, high parallel leakage resistance, Rp.

C2 R/C (or TRW) 15-497 pF straight line frequency variable capacitor, Rp on the order of 20 megohms. No. 107-C-522; FSN 5910-546-9239. Fair Radio Sales cat. no. C123/URM125

C3 same as C2.

C4 same as C2.

C5 0.02 uF polystyrene.

D1 selected (by listening) Radio Shack 12101 3RT germanium diode.

L1 51 turns 100/44 litz on 5/8" dia. x 1-3/16" long ferrite rod, u(eff) = 10.33;
length = 1-35/64"; L = 146.6 uH; Co = 4.54 pF; Q @ 0.5 MHz = 649

L2 36 turns 660/46 litz, basket-wound over-1, under-1 on 5" dia. 13-point form;
length = 1.9375"; L = 185.6 uH; Co = 7.40 pF; Q @ 0.8 MHz = 1134

L3 36 turns 660/46 litz, basket-wound over-1, under-1 on 5" dia. 13-point form;
length = 1.9375"; L = 185.7 uH; Co = 7.40 pF; Q @ 0.8 MHz = 1060

L4 42 turns 660/46 litz, basket-wound over-1, under-1 on 4-1/4" dia. 13-point form; length = 2.25". L= 186.7 uH; Co = 6.45 pF; Q @ 0.8 MHz = 1082

R1 500 k-ohm pot.

S1 DPDT miniature toggle

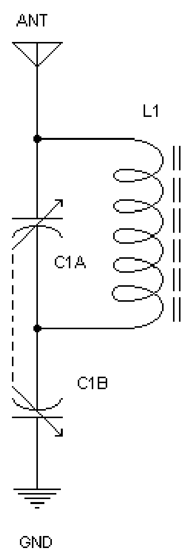
T1 UTC A-27: input transformer --100 k-ohm primary; secondary taps, 50 to 600 ohms -- around 200 ohms seems best with the RCA phones below.

PHONES: RCA MI-2045 sound powered phones, known as "Big Cans" in the trade.

All variable capacitors have vernier drive dials.

Lyonodyne 17

The "Tuggle" Front End



C1 is a two gang air variable

Special Thanks to

Mike Tuggle

of Hawaii (lucky dog!)

for the use of the above information.
And taking the time to write the above article.

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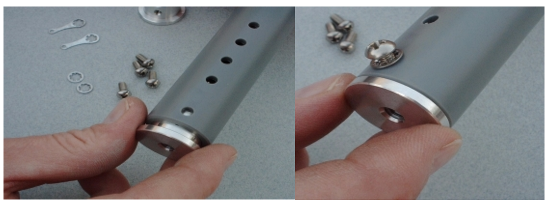
80 Meter Coil Kit Assembly

Parts:

PVC coil form, light gray (1)
Aluminum end caps (2)
8-32 x 3/8” stainless Phillips screws (4)
#8 internal tooth lock washers (4)
#8 ring terminals (2)
#22 Enamel insulated copper wire

The coil is assembled using the 2 larger end caps, the larger light gray PVC coil form and 4 of the 8-32 x 3/8” screws. Four #8 lock washers and 2 #8 ring terminals are also used.

Two lock washers go on one side to secure the screws and the 2 ring terminals are used for connecting the coil windings.



Insert the end caps, align the screw holes and insert the screws.

Once the end caps are installed,, the coil is ready for winding.

Start by winding 145 turns on the coil. This should almost entirely fill the space between the last hole set before the endcaps At this point, you may prefer not to solder one end of the coil. This will allow adjusting the coil without unsoldering.

Once you are happy with the coil you may choose to crimp or solder the wires to lugs or leave as is.

The Completed 80 meter coil

Set up the PAC-12 antenna with radials and the 80M coil in place and check the SWR using a bridge or analyzer. Collapse the whip sections until minimum SWR is achieved.

If more than one full section is collapsed, then remove a turn or two from the coil and repeat the test.   We recommend tuning so that approximately one half of a telescoping whip section is collapsed at the lowest frequency end of the band.

To go to a higher frequency, simply collapse the whip a bit as necessary to achieve a match.

Alkaline battery charging circuit

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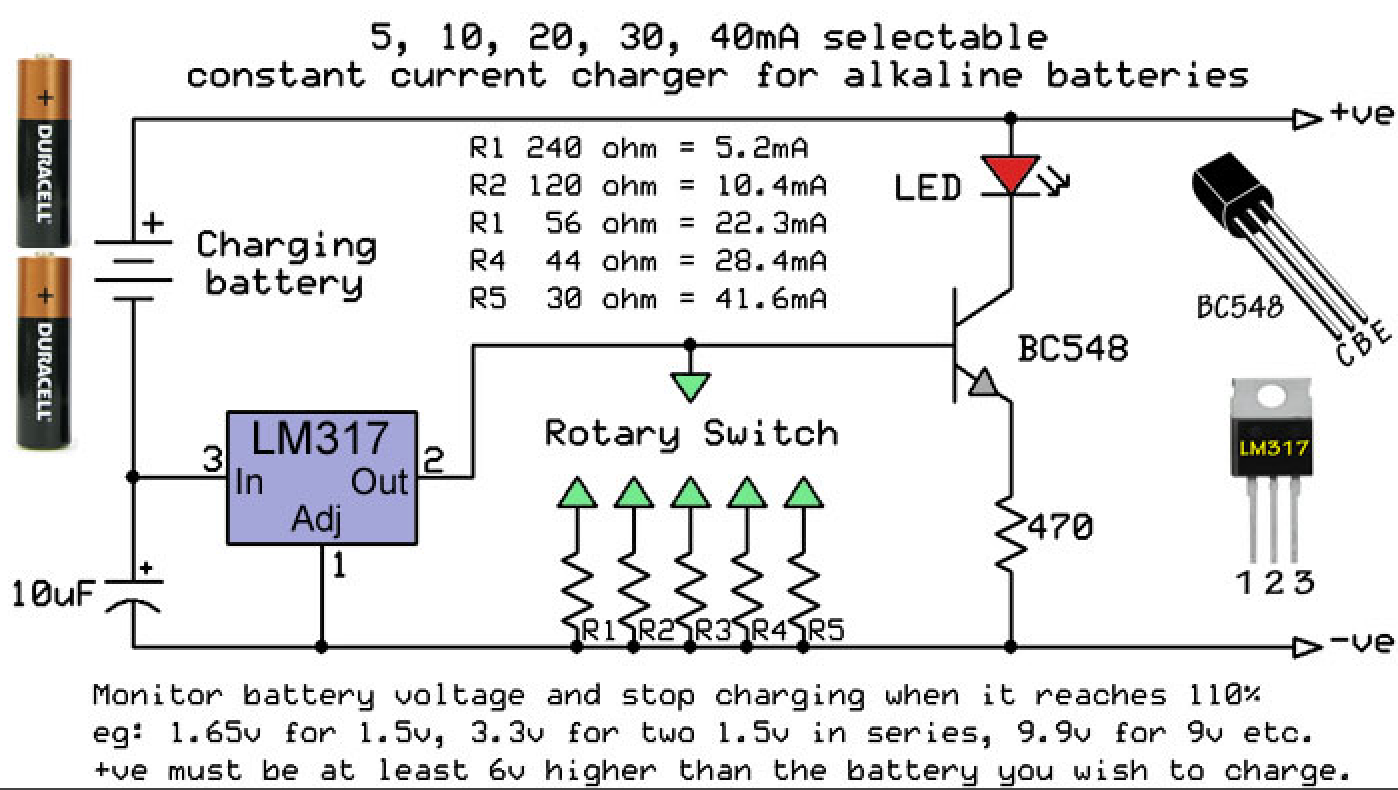

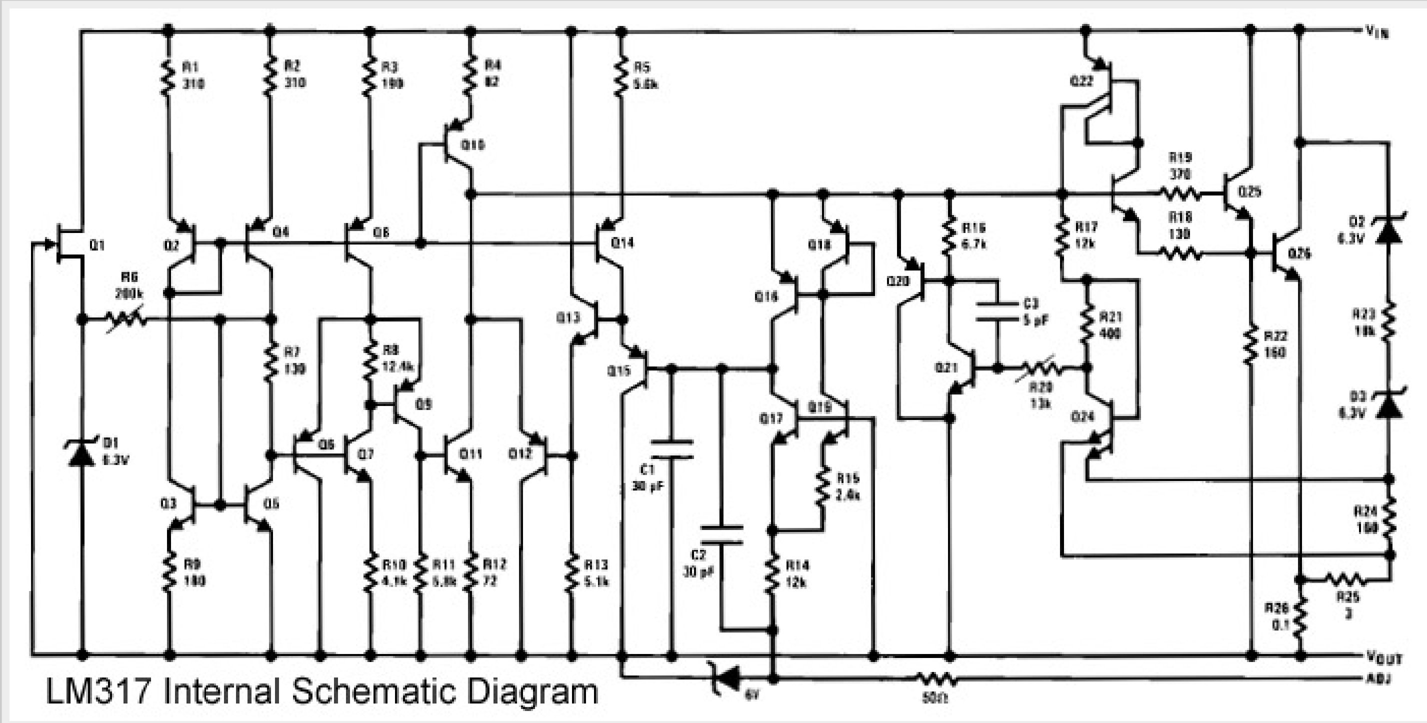

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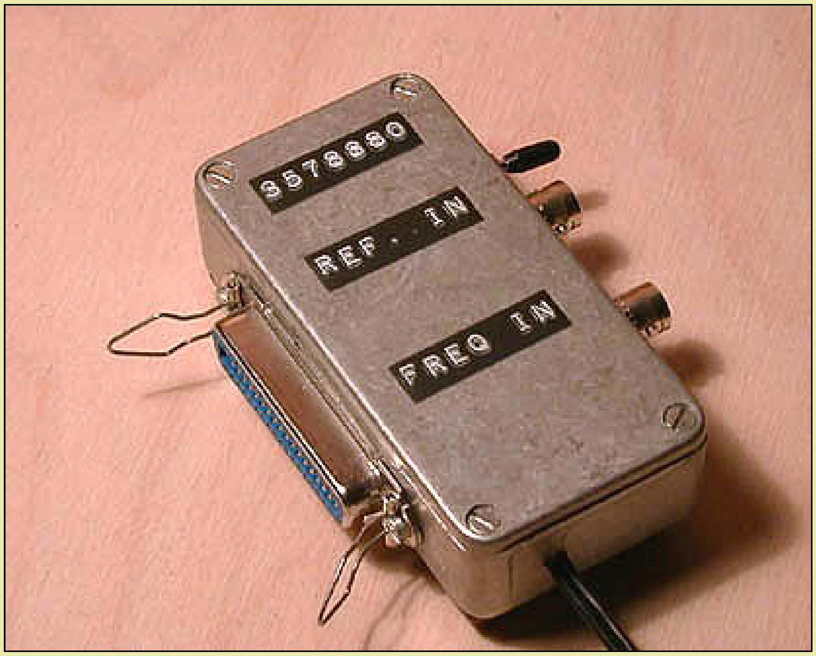
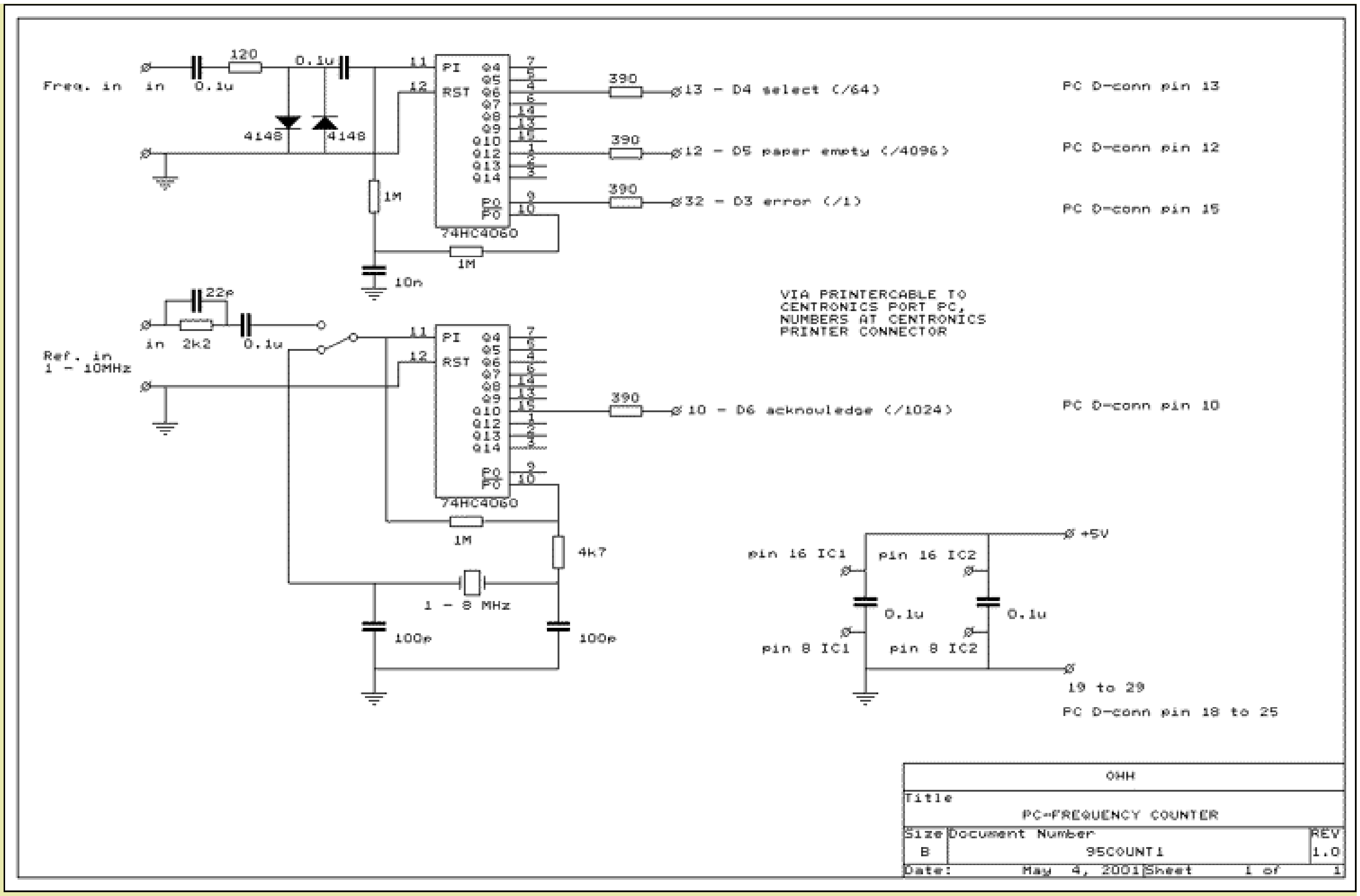
SIMPLE 80 MHz FREQUENCY COUNTER FOR PC (DOS)

(1995)



Low budget frequency counter with only two chips.
Connect it to the printer port. It works only in DOS mode, not in Windows!

Only two simple chips and a few components
This is a design of a simple frequency counter up to 80 MHz. It can use it's own internal crystal oscillator or an external reference frequency. It works from 100 kHz to 80 MHz, for square wave signals it goes down to frequencies of 20 Hz. So if you want to use it for LF, then add an op-amp amplifier / comparator to make a square wave of the sine wave.



Circuit diagram

[big diagram](#)

Working principle

Normally, frequency counters count the number of periods during for example 1 second. This counter is different. It measures the exact time of a number of periods and the frequency is calculated. This has the advantage that the accuracy is the same for all frequencies. It is possible to measure the frequency of a 1 kHz LF signal with an accuracy of 0.01 Hz when using a measuring period of 1 second. For normal frequency counters the accuracy is 1 period or 1 Hz.

The PC measures frequencies using its internal timer. However, the accuracy of the timer of the PC is not good enough. Therefore, the first step of the test is to measure a reference source (the internal crystal oscillator or external reference oscillator) and calculate the required correction for the PC timer inaccuracy. Then the actual frequency measurement is carried out and corrected with the correction factor for the PC timer inaccuracy.

As only LF frequencies can be measured with the PC, RF frequencies are prescaled to LF frequencies with use of a simple preamplifier / prescaler, a 74 HC4060 chip.

Running the program

Connect the counter to LPT1 via a Centronics printer cable.

For accurate results, your PC should run in DOS mode, not in Windows. Start the program by typing FREQPC.EXE REFERENCE_FREQUENCY. In my case FREQPC.EXE 3578880, as the exact frequency of the crystal oscillator of my counter is 3578880 Hz. When I use my 10 MHz reference standard, the command is FREQPC.EXE 10000000 or FREQPC.EXE 1e7.

No time out

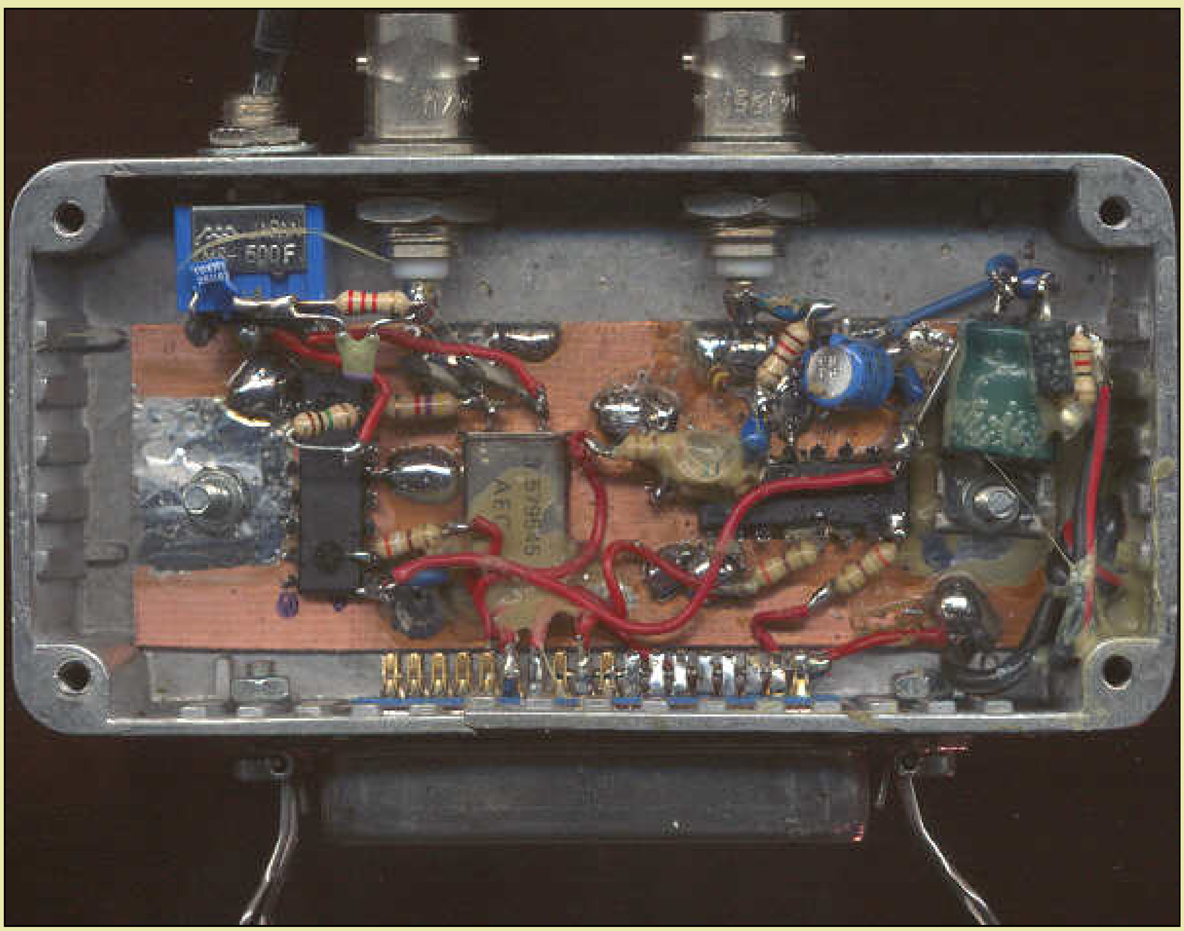
For maximum accuracy, there is no timeout during the measurement. Therefore it is possible that the program halts if the input signal is removed. So the procedure is: Stop the program and then remove the input signal. Before the measurement begins, the program checks if there is an input signal. Although the circuit could get it's supply from the printer port, I use a separate 5 V supply for better performance.

Download the program(s)

- FREQPC.ZIP (35k) containing FREQPC.EXE DOS Program and FREQPC.C Source code.

Performance

Frequency (MHz)	Sensitivity (mV RMS)
0.1	10
1	3
10	10
30	30
50	100
80	150
100	200
120	500
Accuracy:	1e-6



Inside view

The PC program, here opened in Windows, but use it only with DOS for accurate results!
Use the up-down cursor keys to select, right cursor key to activate a menu choice and left cursor key to return.

BACK TO INDEX PA2OHH

ROMANIAN JOURNAL OF INFORMATION SCIENCE AND TECHNOLOGY
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Radiation Performance of an Elliptical Patch Antenna with Three Orthogonal Sector Slots

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Abstract. The paper presents design and radiation performance of an elliptical patch antenna with three orthogonal sector slots and its performance is compared with that of a conventional elliptical microstrip patch antenna (EMPA) operating under similar test conditions. The proposed elliptical microstrip patch antenna has two sector slots along the major axes aligned opposite to each other and a sector slot orthogonal to these two slots and aligned along the minor axis. The location and dimensions of these sector slots are optimized to obtain improved bandwidth close to 10.96% which is nearly four times higher than that of a conventional EMPA tested under identical test conditions. The gain of antenna is marginally improved still it needs further improvement. The measured E and H plane co and cross polar patterns of modified antenna are also present for better understanding. The modified antenna meets the bandwidth requirements for the IEEE 802.11 a5 wireless local area network (WLAN) applications.

Key-words: elliptical patch antenna, bandwidth, sector slot and wireless local area network.

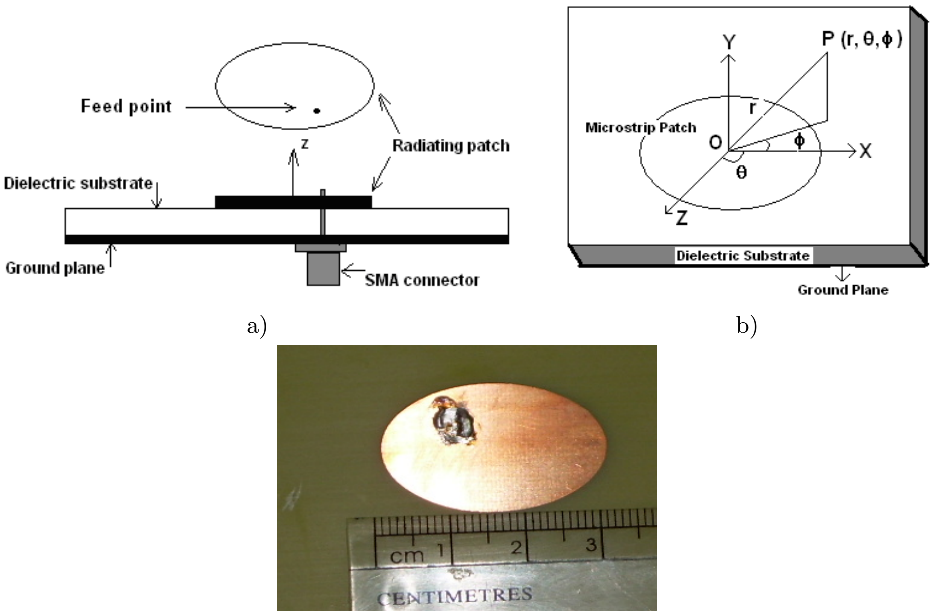
1. Introduction

The recent growth of wireless communication systems has produced a great demand for compact antennas which may fit inside the handset without protruding

out. The most admired structure among the miniature antennas is the microstrip patch antenna. Microstrip patch antennas provide significant advantages such as low profile, low weight, relatively low manufacturing cost and polarization diversity [1]. However, the bandwidth of microstrip antennas is inherently narrow (of order of a few percent) and gain is poor. Therefore, researchers are exploring methods and techniques to design wideband patch antennas with improved performance [2–4]. With the application of slot feeds and thick and air-filled dielectric substrates of very low permittivity, the bandwidth of patch antennas can significantly be improved [5–6]. Further improvements can be made by using parasitic patch and larger slot [7–10]. The proposed antenna is a compact structure, having effective patch area less than that of a conventional elliptical microstrip patch antenna but has much improved performance than that of conventional elliptical microstrip patch antenna. Such an antenna may find application in the IEEE 802.11 a5 communication standard applicable for WLAN communication systems. The antenna geometry is simulated by applying method of moments based IE3D simulation software [11].

2. Conventional elliptical patch antenna

In this communication, first the performance of an elliptical microstrip patch antenna shown in Fig. 1(a) and 1(b) having major and minor axes dimension $a = 1.5$ cm and $b = 1.0$ cm respectively is simulated with IE3D simulation software.



c)

Fig. 1. a) Side view of antenna geometry; b) considered antenna with coordinate system; c) top view of elliptical microstrip patch antenna.

Later this antenna as shown in Fig. 1(c) is printed on epoxy/ glass (FR-4) substrate having substrate relative permittivity $\varepsilon_r = 4.4$, substrate thickness $h = 0.159$ cm, substrate loss tangent $\tan\delta = 0.025$ with infinite metallic copper ground plane. Antenna is feed through inset probe feed arrangement (SMA connector) with 50 ohm feed line.

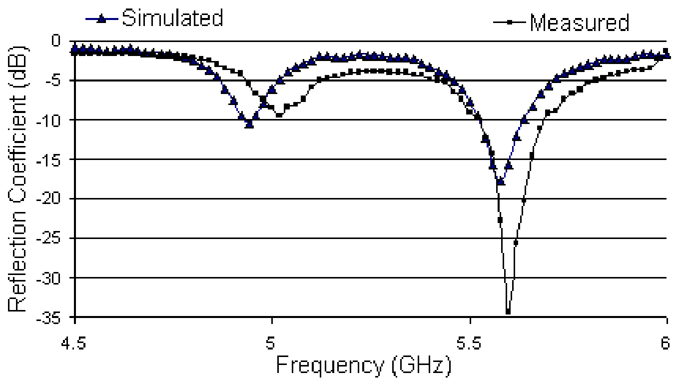


Fig. 2. Simulated and measured variation of reflection coefficient with frequency for elliptical microstrip patch antenna without sector slots.

The simulated and measured variation of reflection coefficient (S_{11}) with frequency is shown in Fig. 2 which indicates that antenna shows to resonance. At first dip the simulated and measured frequencies are 5.01 GHz and 4.94 GHz whereas for second dip the simulated and measured frequencies are 5.61 GHz and 5.574 GHz which are in good agreement. However the first dip corresponding to frequency 5.01 GHz may be considered as non-resonating frequency since the reflection coefficient value is very low and the gain of antenna at this frequency is also very poor. The simulated impedance bandwidth corresponding to second frequency 5.61 GHz is 3.2% which is close to the measured impedance bandwidth of antenna 2.26% with respect to resonance frequency 5.574 GHz. The measured value of VSWR of antenna at second resonance frequency 5.574 GHz is 1.3 which is close to unity and indicates good matching of antenna and feed network. The VSWR is better than desired 2:1 value at frequency of interest.

The input impedance presented at the resonance frequency is (39.17 +j 4.30) ohm which also indicates fair matching between antenna and feed network. The measured gain values of antenna at two frequencies are around 0.15 dBi and 2.69 dBi respectively which are much lower than desired gain of antennas for modern communication systems. These results suggest that conventional elliptical patch antenna in its present form is not suitable for application in modern communication system hence this antenna is modified by introducing three sector slots in this patch and the performance of modified elliptical patch antenna is presented in next section.

3. Modified elliptical patch antenna

The simulation and measured results from a conventional elliptical patch antenna reported in previous section indicates that it has narrow bandwidth and low gain. This

antenna geometry is modified by introducing sector slots on the radiating patch. The proposed elliptical microstrip patch antenna has two sector slots along the major axes aligned opposite to each other and one sector slot orthogonal to these two slots and aligned along the minor axis as shown in Fig. 3. The radius, sector angle and location of center of these slots are optimized to obtain best performance. It is realized that on making radius and sector angle of each sector slot 8.0 mm and 20° respectively, the performance of antenna improves to a great extent. Under this condition, center of each slot is 4.0 mm away from the center of the elliptical patch.

The simulated and measured variation of reflection coefficient (s_{11}) with frequency for elliptical microstrip patch antenna with sector slots is shown in Fig. 4 indicates that with the loading of sector slots, both lower (5.01 GHz) and upper frequencies (5.61 GHz) shift to the lower frequency side (4.93 GHz and 5.31 GHz) respectively. The simulated S_{11} curves corresponding to these two frequencies approach to each other and partially overlaps to provide improved impedance bandwidth close to 690 MHz or 13.15% with respect to the central frequency 5.12 GHz. The measured resonance frequencies are 5.012 GHz and 5.236 GHz while measured impedance bandwidth is 560 MHz or 10.96% with respect to central frequency 5.11 GHz.

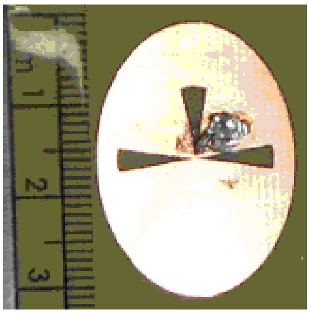


Fig. 3. Geometry of elliptical microstrip patch antenna with sector slots.

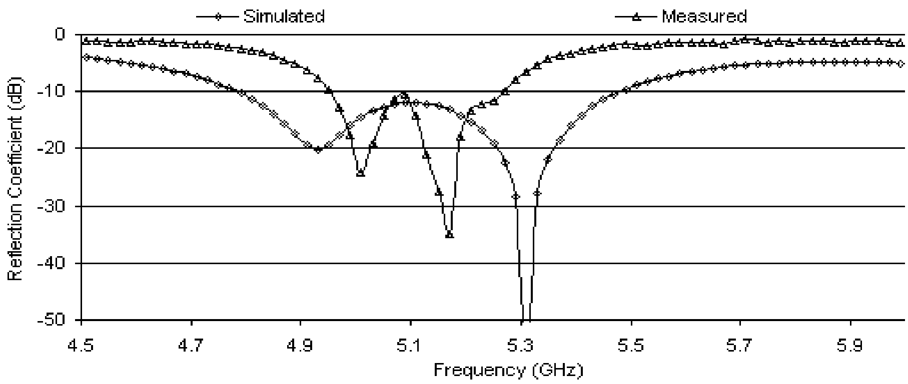


Fig. 4. Simulated and measured variation of reflection coefficient (s_{11}) with frequency for elliptical microstrip patch antenna with sector slots.

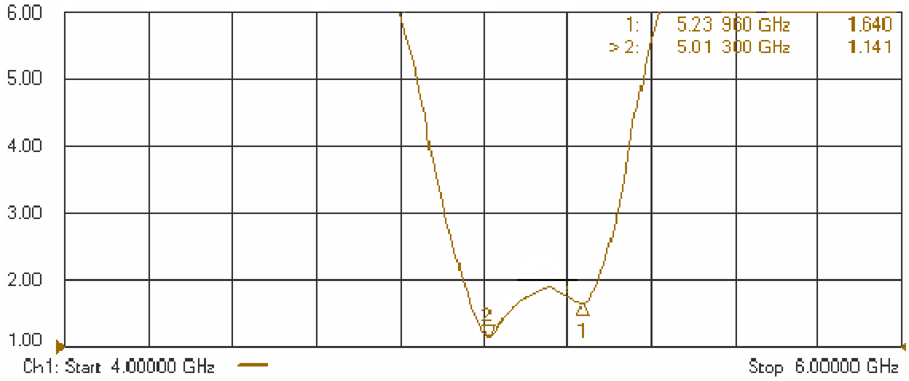


Fig. 5. Measured variation of VSWR with frequency for modified elliptical microstrip patch antenna.

The measured VSWR and input impedance variations of modified elliptical patch antenna with frequency are shown in Figs. 5 and 6 respectively. The VSWR at both frequencies is better than desired 2:1 value (1.64 and 1.14). The input impedance presented at two measured frequencies 5.01 GHz and 5.23 GHz are (56.51 +j 2.067) ohm and (33.63 − j12.28) ohm respectively which again indicates fair matching between antenna and feed network. The measured gain of antenna at the two resonance frequencies are presented in Table 1 and are compared with that of a conventional elliptical patch antenna tested under similar test conditions. The gain of modified elliptical patch antenna is improved in comparison to that of conventional elliptical patch antenna reported in the previous section.

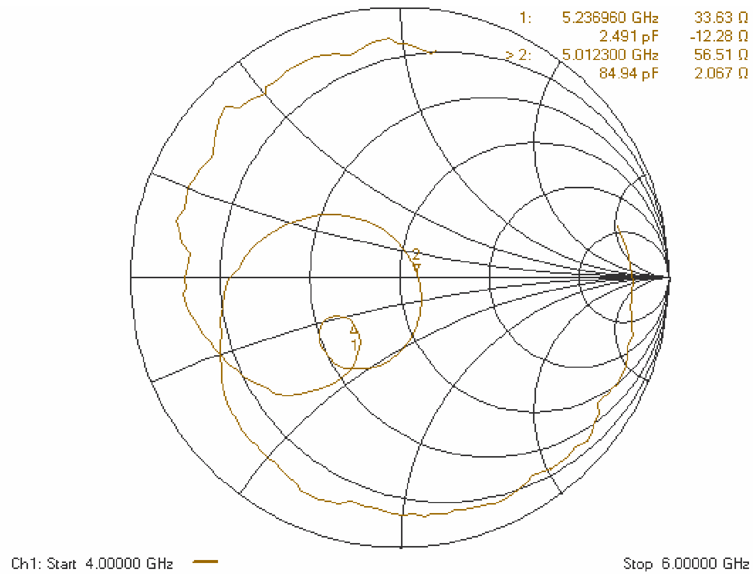


Fig. 6. Measured variation of input impedance with frequency for modified elliptical microstrip patch antenna.

Table 1. Comparison of radiation performances of elliptical microstrip antenna with and without slots

Name of antenna	Resonance frequency (GHz)	Gain in dBi		Radiation Efficiency	Directivity (dBi)
		f_{r1}	f_{r2} ($f_{r2} > f_{r1}$)		
Conventional elliptical patch antenna	5.01 5.61	0.15 dBi	2.69 dBi	22.24% 23.74%	7.42 7.66
Modified elliptical patch antenna with slots	4.94 5.238	0.81 dBi	4.03 dBi	30.92% 36.22%	6.44 7.76

The simulated E and H plane elevation patterns of antenna at four frequencies covering impedance bandwidth region are shown Fig. 7. The patch antenna produces cardoid patterns at all the indicated frequencies, with good gain along on boresight and dropping to 0 dB. The measured E and H plane co and cross polar radiation patterns of antenna at frequency 5.23GHz are shown in Fig. 8. In both E and H plane, co polar patterns are nearly 6dB higher than corresponding cross polar pattern. The direction of maximum radiations in each case is directed normal to the patch geometry and the patterns are more or less symmetrical in nature.

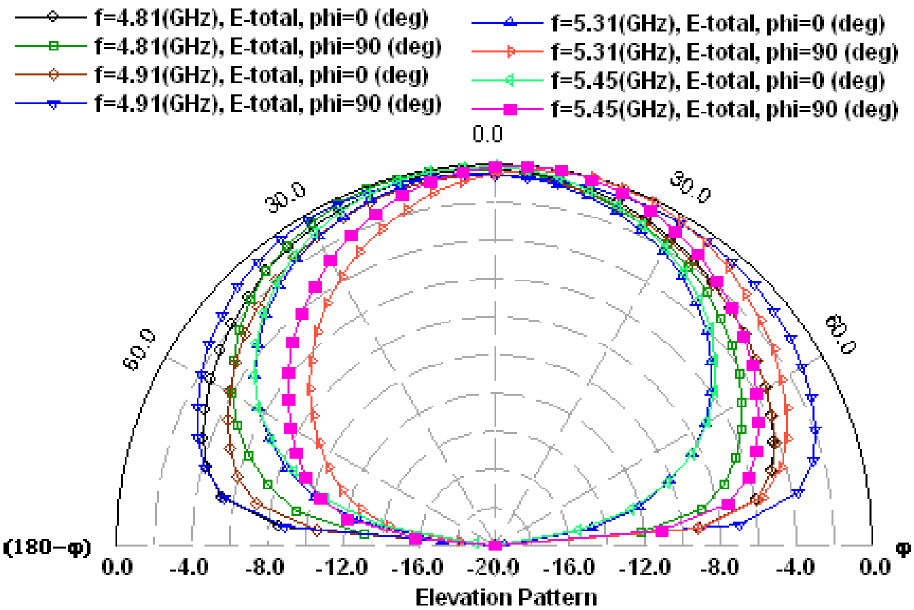


Fig. 7. Simulated E and H plane elevation pattern gain display at four frequencies.

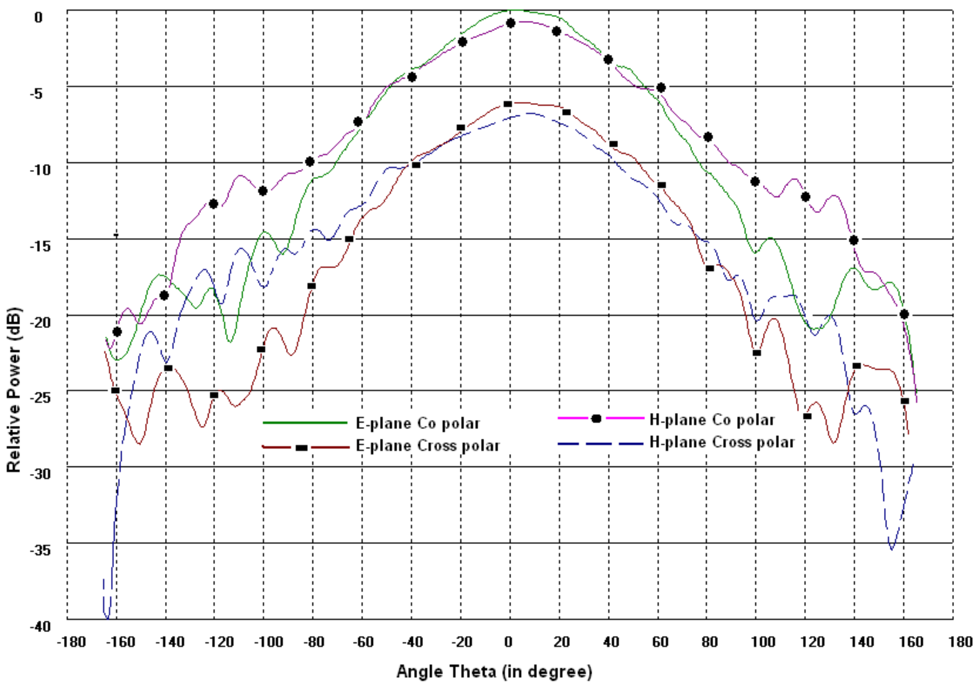


Fig. 8. Measured E and H plane co and cross polar patterns 5.23 GHz.

3. Conclusions

This paper presents the radiation performance of a modified elliptical patch antenna having three orthogonal sector slots. Experimental results are compared with simulation performance for better understanding. It is realized that with the introduction of these sector slots, the effective patch size is marginally reduced but the performance of antenna is significantly improved. Improvement in both impedance bandwidth and gain is realized though gain results need further improvement. The radiation patterns are still stable and the direction of maximum radiations is directed normal to patch geometry. With little more improvement, this antenna may be proved a useful structure for wireless local area networks (WLAN) communications covering the 5.15 to 5.85 GHz frequency bands adopted by IEEE 802.11a5. However there is a slight deviation in simulated and measured values of resonance frequencies and gain of antenna which might be due to the limitations of applied simulation software, fabrication tolerances of antenna and possibility of misalignment of sector slot and feed point during fabrication of prototype antenna for experimentation.

Acknowledgements. Authors like to acknowledge Department of Information and Technology, New Delhi for providing financial support during this work. Authors are also thankful to Dr. S. Pal and Mr. V.V. Srinivasan, ISRO Bangalore for permitting us to use the measurement facilities available at their center.

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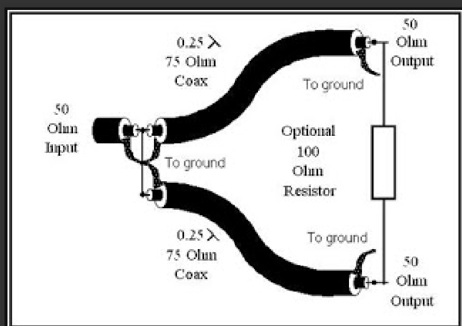
du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Monday, April 23, 2012

Wilkinson Power Combiner / Splitter For VHF



This technology was first used in the FM broadcasting industry wherein most of the solid state rf amplifiers were combined to arrive a higher power levels. The Wilkinson network is reversible that means that it can be used as a power divider to split power equally and it can be also used as a combiner. On this project, it uses a pair of Daiwa 80W rf booster (LA-2080) modified for "class C operation" and was only set at 70W output. Note that each rf amplifier should be identical so that there will be no phase difference on the signals arriving at the combiner network. For 144MHz, 4 pairs of RG-59 was used for the quarter wave section and several RG-58 cables for the patch cable used for connecting the radio transceiver to the Wilkinson input and from the Wilkinson output going to the power meter. Note that the RG-58 cables were cut at half wave of the operating frequency.

The 100 ohm resistor in the splitter section is rated 10W same also to the combiner section. During the test, the 100 ohm resistor at the combiner generates some heat and should have been increased in wattage to 50 or more for safety purposes. It is also necessary to match each amplifier and should have an equal rf output. This can be done by tuning each rf amplifier one at a time while keeping the other unit off. Please be aware that when one amplifier is off, the output power of the combiner is just a quarter of the original power output when all of the rf amplifiers are working together. Once rf output of each rf amplifier are matched then the system is ready for use.

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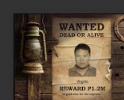

hevirred

Ham since 2000.

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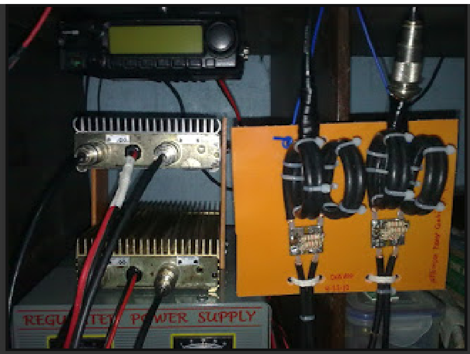

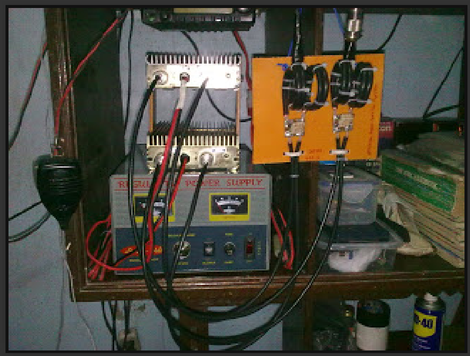

For the input drive of 5 watts I was able to measure 135W output from the combiner network. Please also observe the 100 ohm resistor at the combiner, too much heating means there is an imbalance between the two rf amplifier and should be equalize again. ---73 de du1vss

Posted by hevirred at 1:58 PM

4 comments:

- **jay s** April 30, 2012 at 3:51 AM

  sir, I'm very interested sa project na ito, kaya lang gusto ko try sya sa HF, especially 7mhz...paano ko makuha or formula to get the exact lengths ng coax and yun value ng resistor? thanks.

  Reply

- **_DU1VSS _** April 30, 2012 at 9:46 AM

  sir parang napaka haba na ng quarterwave ng 75 ohm sa 7MHz anyway the technique suggest that it is still possible. yung resistor sir is still 100 ohm pero dapat kung ilang watts ang isang booster mo, dapat ganun din ang wattage ng iyong resistor.

  Reply

- **_DU1VSS _** April 30, 2012 at 4:43 PM

  quarterwave = 984/F(MHz) * 12 / 4 ; the unit is now in inches

  Reply

- **jay s** May 1, 2012 at 7:27 AM

  you're right sir sobrang haba, na-compute ko using the formula you provided. Not practical on HF frequencies. Thanks for the info sir.

  Reply

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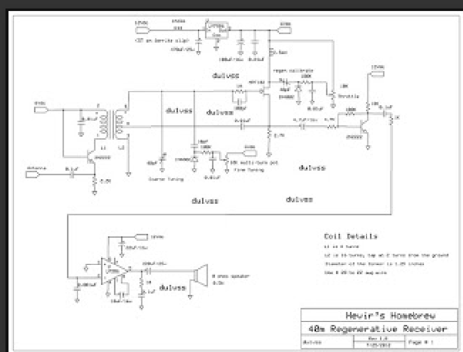
Saturday, August 25, 2012

40m Regenerative Receiver



The first regenerative receiver was invented by Edwin Armstrong in 1914 and was been a standard receiver both for commercial and in amateur use long before the spread of super regenerative receiver. The circuit above was basically derived from the earlier works of Charles Kitchin, N1TEV and was modified for several improvements. Regenerative detectors able to detect nearly all types of signals including AM, CW, single-side band (SSB) and FM despite of its simplicity and fewer part counts. They tend also to consume less power, cost less and are easier to home brew than any other receiver.

The main modification of this project from the original design was the reduction of the variable air capacitor which due to the lack of availability of this item nowadays. It uses two tuning diodes (basically 1N4002 in reverse bias) to control the Fine Tuning and the other one is for the Throttle adjustment. A single transistor audio pre-amp was also included between the main input of the 386 main audio amplifier IC for added audio gain.

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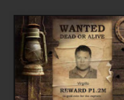

hevirred

Ham since 2000.

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The tuning diodes provide a smooth adjustment of the Fine Tuning and of the Throttle control (regen). Stability isn't a problem at all.. small frequency drift may be noted on the first few minutes after power up which usually requires some warm up period. Once the receiver is up.. minor adjustment may be needed to clarify audio reception in single-side band (SSB).

This project was housed in a plastic casing but the original author suggested that wooden base may be used to avoid interaction with the air core transformer thereby reducing the "Q". First time user may require a little bit of control and manual adjustment specially the Throttle (regen). For AM reception, the detector must be adjusted just before oscillation and for CW, the regen may be moved a little over oscillation. When receiving SSB, the regen may be moved a little higher specially when receiving a stronger station to prevent frequency blocking.

The air core transformer contains the primary and secondary turns of # 22 magnetic wire. The core itself was made of 1.25" diameter of pvc pipe cut approximately 2" of length. Spacing of the primary turns to the secondary turns was about 1/4" but if you want some tight coupling a 1/8" spacing may be fine. The placement of the air core transformer is also important. Avoid placing the core in close proximity of metal objects such as speaker or transformer to avoid any unwanted effects. Placing the 12V power supply inside the receiver is not advisable since it will induce severe hum on the receiver's audio. The 12v wire going out to the external power supply must also be well filtered. I found out that 5 turns of the wire over a ferrite clip is already satisfactory. For my prototype receiver, a wire 10 meters in length acts a long wire antenna provides a sufficient reception of several DX stations heard in my area. Have fun with this project as I did. 73 de du1vss

Posted by hevirred at 5:38 PM

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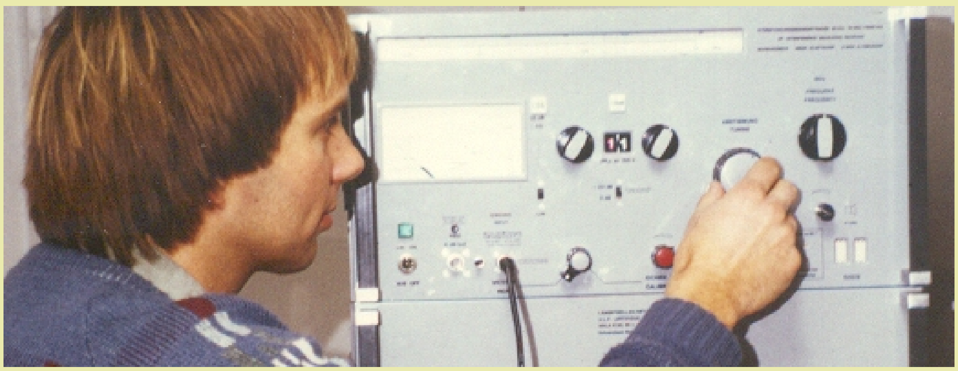
CW RECEPTION WITH AN AM RECEIVER

(1980)

KLIK HIER VOOR DE NEDERLANDSE VERSIE

CW reception with a Beat Frequency Oscillator

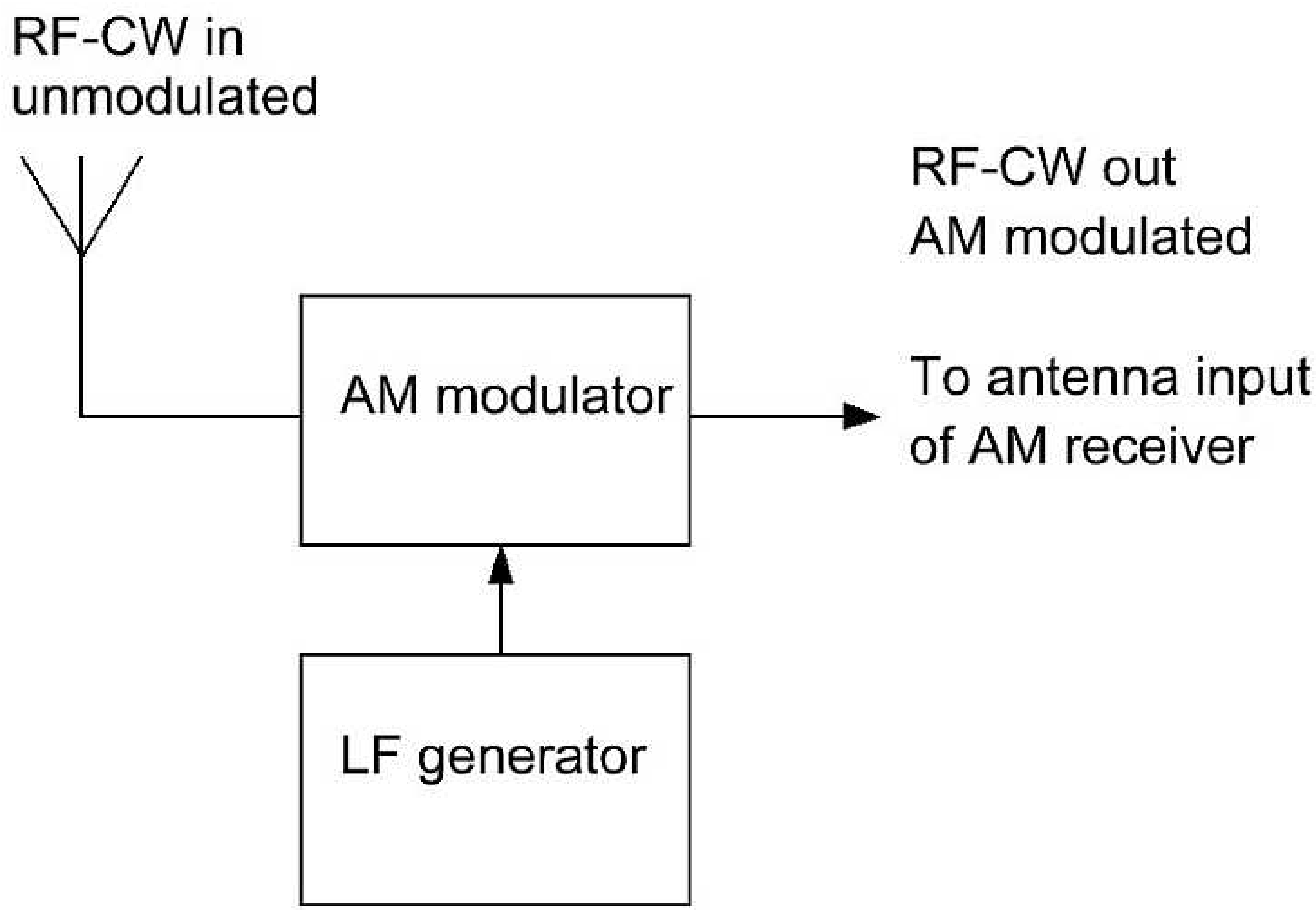
Usually, CW is transmitted as an unmodulated carrier. To make it audible, a BFO (Beat Frequency Oscillator) is used. The frequency of the BFO is a few hundred hertz lower or higher than the frequency of the CW signal. In a detector, a beat tone is generated. That is an audio tone with a tone height equal to the difference of the frequencies of the CW signal and the BFO oscillator. This works excellent, sensitivity is very good and all CW signals can be seperated very good as they have different tone heights, as long as their transmit frequencies are different. A disadvantage is that you can receive only a limited frequency range, namely within an audible bandwidth around the BFO frequency. And if the frequency of your receiver is drifting a little, the audio tone changes too.



In 1980, I wanted to receive CW signals with this AM receiver.
How is that possible without a Beat Frequency Oscillator (BFO)?

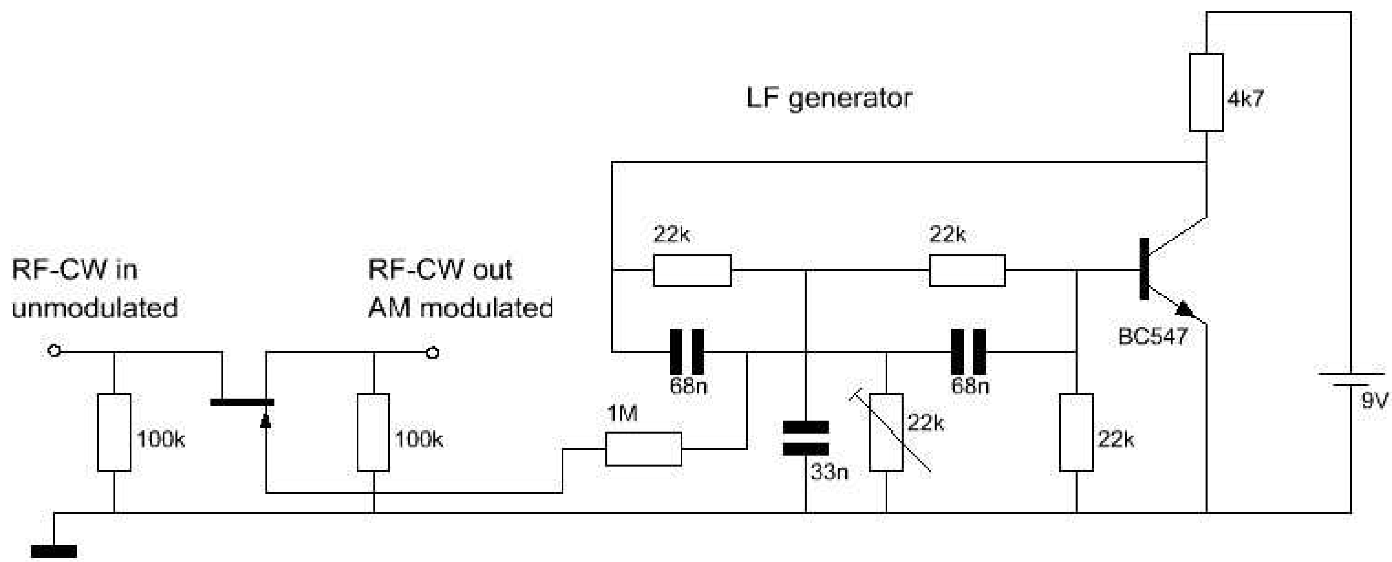
Reception of a CW signal with an AM receiver

When we want to receive CW with an AM receiver, then the RF signal has to be amplitude modulated with a tone. Such an amplitude modulated signal can be received with an AM detector (for example a diode detector or crystal detector).



Amplitude modulation in the receiver instead of the transmitter!

Amplitude modulation in the receiver instead of the transmitter!
I had a very nice AM receiver with a 500 kHz loopantenna. And I wanted to receive the coastal stations transmitting morse code with that receiver. But then the CW signals had to be amplitude modulated with a tone. Then I had the idea to realize the amplitude modulation not in the transmitter but in the receiver. A simple amplitude modulation was placed between the loopantenna and the AM receiver and... it worked! The unmodulated CW carriers were amplitude modulated with a tone before they were presented to the antenna input of the receiver! And the amplitude modulated CW signals were perfectly audible with the AM receiver! Did the frequency of the (not so stable) AM receiver drift a few kilo Hertz, no problem, the audio tone remained the same because there is no beat tone used. Not only that single signal that you receive is modulated with a tone, but al signals!



The diagram of the simple amplitude modulator between antenna and AM receiver input.
Of course it is possible to realize such an amplitude modulator in many other (and better) ways.

New idea?
When I made and tried this circuit in 1980, I thought it was quite a nice idea. But was it really such a new, unique idea? Not so long ago I saw a PDF version of an ARRL handbook from 1936. And in that book, the same idea was described. The unmodulated CW signals were amplitude modulated with a tone in the first tube of the intermediate frequency amplifier. The grid was connected to a low frequency oscillator. By means of the variation in the gain of the tube in the rhythm of the low frequency signal, the CW signal became amplitude modulated. So it was already a very old idea...

Other applications
Of course the disadvantage is that you do not have any audio selectivity, all CW signals do have the same tone height. The sensitivity of such a receiver is also not so good. But there are other applications for this decoding principle or making unmodulated signals audible with an AM receiver.
You can use this principle for a wide band AM receiver. You can make for example a monitor receiver that receives the whole CW part of a certain amateur band. When there are conditions, you do hear all CW signals on the whole band (with the same tone height...).
Or you can make a monitor receiver for your CW signals: A whip antenna, the amplitude modulator and a wide band diode receiver (1 - 30 MHz) with audio amplifier. You can use this receiver as side tone and level indicator. When the tone becomes louder, then the signal is stronger.
Or you can make a very sensitivie RF detector. As the signals are amplitude modulated, you can use a simple AC amplifier after the diode detector instead of a difficult to make and temperature drifting DC amplifier. Or even your sound card of the PC!

Remarks
It is very important to design the circuit so that the signal of the LF generator does not disturb the other circuits after the detector, or radiates into the audio part of the receiver.
And in the ARRL handbook from 1936 it is adviced to apply this amplitude modulation also in a normal CW receiver with BFO. With extra amplitude modulation, the CW signals do sound much better and that makes listening to CW signals less tiring!

[BACK TO INDEX PA2OHH]

My PIXIE Experiments

My PIXIE interest started about two years ago when I was looking for a simple transceiver to be built by my builders group that would give a successful contact among the members and provide an effective tool for exploring the art of building a working radio. My first PIXIE was built for show and tell to the group. I built it "Manhattan Style" using parts scrounged from old VCR's , Telephones, Computer modems, etc. From that time on I was hooked on the little radio. My 1st is pictured at the right. It used a switch to offset the frequency between transmitt and receive.

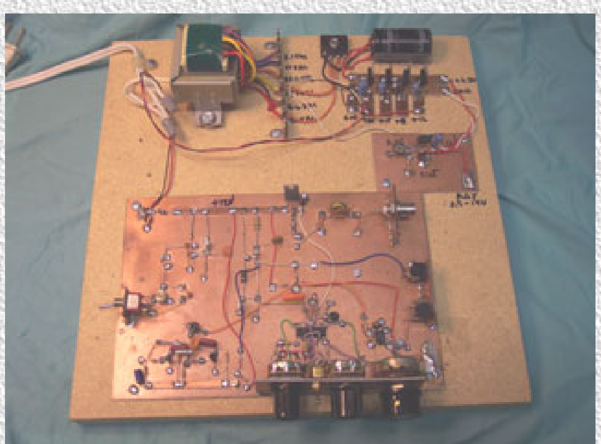
After operating it for a short while, I noticed the little things that escape you when your first doing a project like this. My CW skills are not the best and the radio didn't have a sidetone Oscillator so I could hear what I was sending. After looking at a number of designs I settled on the one in W1FB's book using two NPN transistors. I changed another resistor in the PIXIE so that the audio amp didn't mute completely and I was in business. I made some local contacts with my builders group members but any DX seemed to elude me. My side tone was built on a separate piece of PC board and wrapped in Black tape to keep it from shorting out the other stuff and "stuffed" into the Altoids can. It is pictured at left.

After some more study and revising my layout to accomidate changes and having much difficulty modifying my first PIXIE. I decided to build unit #2. It has the side tone oscillator laid out on the main board and another automatic switching circuit to provide the frequency offset for the transmitter every time the key was depressed. It really worked better and I tried numerous times to work some DX and was finally successful working a station 875 miles away. But the QRM was terrible. But even with that, the little radio performed well with only 440 Milliwatts of RF output on 40 meters to a simple Dipole antenna.

Still thinking I could improve the number of contacts per CQ, I surmised that the little

radio wasn't putting out enough power to be heard. So I set about to build myself a QRP Gallon Linear. I settled on the design from NORCAL that was used to boost the output of the SMT transciever. It was a simple linear using a Radio Shack Fet transistor. I added a switching circuit from W1FB's Design Notebook to switch the linear inline for transmit and out of line for receive. Now my little radio had a 3.5 watt voice and I was heard more often. The linear is pictured left.

Since my CW skills are slow (15 wpm Max) and pushing down a hand key for a long period of time makes my arm ache. I built myself a computer interface that would key the PIXIE and my ROCKMITE by just typing on the keyboard using the HAMCOM program. That really eased the stress on my old bones and made operating much easier. The PIXIE receiver does not have enough signal strength to lock up the CW decoder in the HAMCOM program but it does sometimes lock up with the ROCKMITE receiver and is great for reading the mail. From the success of the decoder I don't think I am the only one using this method.



So what is next? Well, The QRM problem is the next big hurtle to solve. There are a couple of interesting filter circuits that I am trying to get to work that should fit between the detector and the LM386 audio amplifier. To ease the strain of development of modifications for the PIXIE, I have devised a LARGE SIZE PIXIE that I built on a piece of particle board that I use for building my modifications on. It is pictured at left and has one of the audio filter circuits already built on it ready for some serious testing. Another modification I would like to make on Linear is to switch in a receiver RF amplifier/preselector when the linear is in the receive position. I think that would help the PIXIE's receiver sensitivity.

I will keep working on this little wonder as a matter of choice. It is the ultimate in "bare bones" radios. By all accounts, it is about as minimal as you can go and still have something that works. It is a great Club builders project. Most of the parts can be scrounged from defunct consumer electronics such as VCR's, Telephones, Computer Modems, Boom Boxes, and the like. It is simple to build Manhattan Style which eliminates the need for a Printed Circuit board. About the only parts that you really have to buy are the crystal, the LM386 Audio Amplifier and the core to wind the output filter inductor on. It is about as close to a "FREE" radio as you can get. Here is a picture of my complete PIXIE station that I take

with me when I travel. The power supply in the black block is 8 AA penlite batteries in two 4 battery holders hooked in series to give me 12 volts. The headphnes are a pair of Walkman type made by Koss that I got at Walmart for $5.99 and has a small volume control mounted in the cord. The Key is an old Radio Shack Hand Key that I have had for years. If you don't have a hand key there is a number of ways to make one. (one design uses a large paper clip and works great). The PIXIE is set to operate at 7040Khz and my normal antenna is the simple dipole strung up as best I can where ever I am visiting. A modified PAC-12 antenna for 40 meters has also been tried but the dipole just seemed to work better, even at low altitudes.

Here are the links to the information that I studied on the PIXIE Transceiver concepts that I used to make my PIXIE's.

http://www.al7fs.us/AL7FS2.html this link to Jim's site explains how his adaptation of the PIXIE works and pictures and information on how his was built.

http://www.qsl.net/we6w/text/pixie.html This link has a wealth of information on the PIXIE and the PIXIE II and should give you more information for building your PIXIE.

http://www.qsl.net/wa4chq/radio.html#Pixie2. The model of this PIXIE is called the DIXIE PIXIE. It is another adaptation of the PIXIE theme. More ideas and thoughts on how you should build your PIXIE.

http://www.qrpp-i.com/ This site is the mother load of articles on the PIXIE transceiver. It contains many links to sites with building tips, available kits, and operating hints in building and using the PIXIE.

If you need additional information on My PIXIE Experiments, feel free to email me, I would be glad to hear from you. You can email me at: dhassall@zianet.com

Back to Dave's Ham Radio Projects page

Many thanks to J.Arthur for the excellent revision of the following text

250 W S.M.P.S. with Power FETs

Safety Instructions

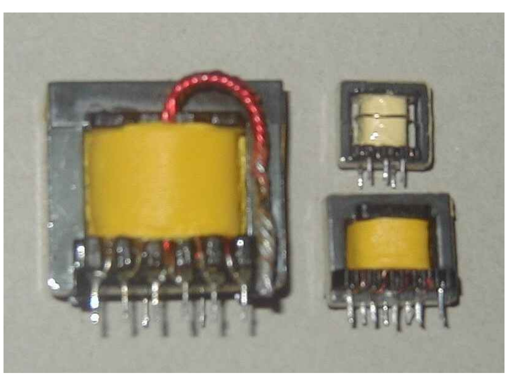
Caution mortal danger: The following circuit operates at a mains voltage of 230 Vac. Because of rectification, some of the components carry dc voltages of more than 322 V. The circuit should be disconnected from the mains and de-energized before any work is attempted on it. Note that capacitors located on the primary side will be charged with high voltage for several seconds even after switching of the mains voltage.

Experiments with the PC power supply encouraged me to produce an "improved" design. Like the original design, the new power supply is also a forward converter with a half-bridge topology. The differences to the modified PC power supply consist of the following items: 1) two power FETs are used instead of bipolar transistors as power switches, 2) a synchronous rectifier on the secondary side instead of power diodes, 3) the elimination of a switch driver stage (current-proportional control), and 4) a simpler over-current and over-voltage monitor. With the magnetic components (output transformer, driver transformer, chokes...) stripped from a PC power supply, the new power supply delivers a max. power output of 250 W with efficiency up to 90 %. The power supply can handle 20 % overload for a short duration.

Magnetic components from a PC power supply

The magnetic components of AT-style PC power supplies don't vary much. They are usually designed for a switching frequency of 25... 40 kHz and a power output of 200... 240 W. The transformers on the S.M.P.S circuit boards are to be found often in either a small, or a somewhat larger size. I am not able to say, whether the larger size brings more power or if it is only an older design. [Note: the larger size is usually found in flyback supplies. ja] For the new power supply I preferred the larger transformers because they have more space available for additional turns in all three transformers. The smaller transformers are completely filled with copper and insulation, and are therefore only marginally suitable for modification.

Fig. 1: Transformers from the PC power supply

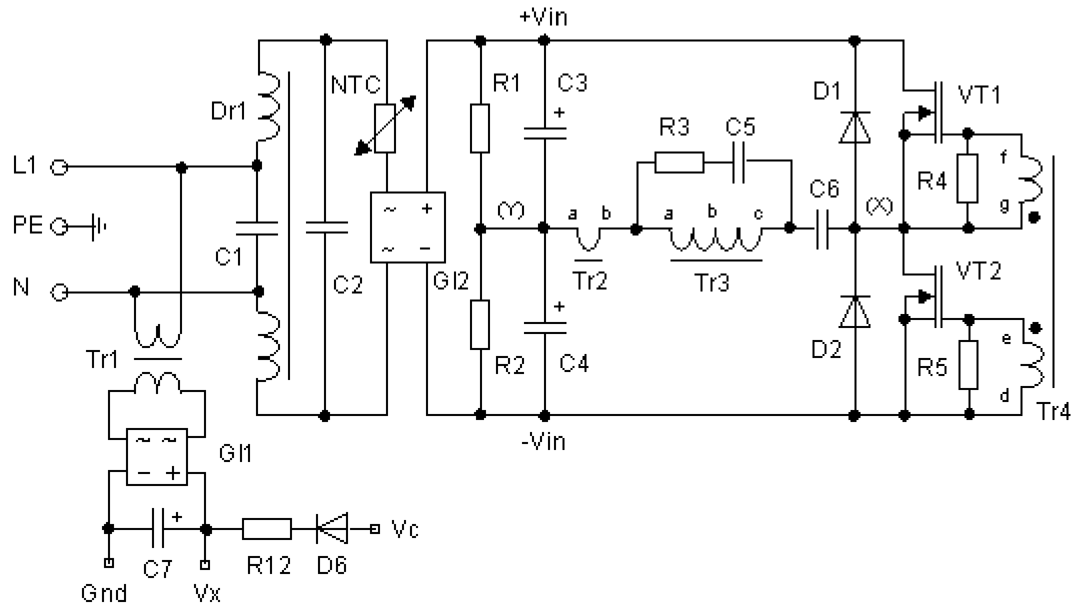


Mains rectifier and filter

This circuit section is uncomplicated. The common-mode choke Dr1 (mains filter) is followed by a NTC resistor for limiting the inrush current. Its resistance amounts to 5 ohms cold, and after few minutes the warm resistance is less than one ohm. The 230 Vac rectifier is generously specified at 4 A, so no

cooling is necessary. The values of capacitors of C3 and C4 is determined by the allowable ripple voltage Ubr, and the number of mains-voltage half-cycles to be bridged [i.e., 'hold-up' time required]. For Ubr = 25 V and zero half-cycles, two 470 uF capacitors in series are sufficient. This specification applies to maximum load during low mains-voltage Umin = 230 Vac - 15%

Fig. 2: Filter, rectifier and power switches



Power switches

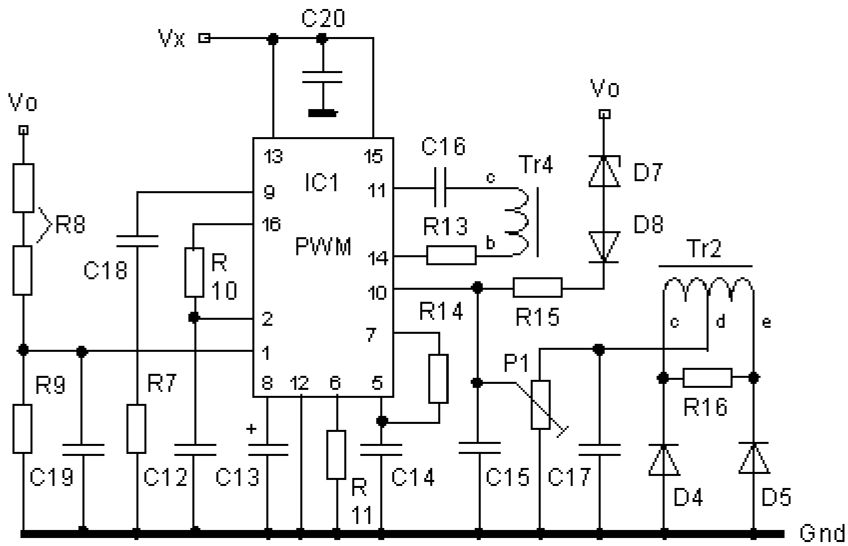
FET power switches were used for their short rise and fall times and the easy, component-saving driver circuit. If one is content with switching times of 100 ns, a small driver transformer and two gate resistors suffice for driving the FETs. Unfortunately, there's no way to avoid re-winding the transformer secondary, which is needed to supply the proper gate voltages. The single turn and 2 x 8 turns must be removed from transformer Tr4. Instead of this, wind 2 x 16 turns (bifilar). A winding ratio of 16 : 26 and a 20 V control signal from IC1 provides the FETs' gates with 10 V of drive, enough to achieve the FETs' specified Ron of 0,75 ohms and thus very small conduction losses. Dynamic (switching) losses at 50 kHz are negligible with the before-mentioned switching times. The PWM IC drives enough current to switch the FETs on and off quickly. Increasing the switching frequency from the original 33 kHz (PC power supply) to 50 kHz (new power supply) allows the transformer to more energy. You can't, however, arbitrarily increase frequency with a given transformer; the transformer is only usable over a certain frequency range. Experiments showed the transformer can cope with a factor of 1.5 without problems (overheating).

Control circuit

After switching the 230 Vac mains voltage on, an auxiliary voltage from the small 50 Hz transformer Tr1 powers the PWM controller SG3525. The error amplifier in the SG3525 compares a portion of the 13,8 output voltage (actual value) with the internal +5,1 V reference voltage (set value) and forms from it an error voltage for the pulse width modulator. The modulator sends alternate control pulses via its two outputs to the transformer Tr4. The pulse duration is inversely proportional to the error voltage. Increased loading on the +13.8 V output makes for wider pulses; lighter loading causes narrower pulses. The switching frequency of the power switches is 50 kHz. For higher frequencies the FETs are usable, but not the magnetic components salvaged from the PC power supply. The oscillator frequency is determined by the components attached to pin 5 and 6. R14 determines the dead time, which is absolutely necessary to avoid simultaneous conduction of the two switching transistors. Since they lacking the storage time limitation of bipolar transistors, a very small value can be set for the the new

FETs switches. With 1 us deadtime and 20 us period duration--50KHz--the FETs can theoretically conduct 95 % of the time and thus deliver energy to the output. Soft-start capacitor C13 charges after power-on, producing a soft-start with narrow pulses initially, then wider control pulses afterwards. Terminal (a) of the driver transformer Tr4 remains free. Just one half (26 t) of the primary turns (b - c) and the 16 turns of the secondary winding are sufficient to provide the necessary ratio of 0,6.

Fig. 3: PWM control and monitoring



Monitoring functions

Two protection circuits are included in the new power supply. The transformer Tr2 is used as current detector and produces a voltage across R16 that's proportional to the current flow through the power switches. If the voltage at the shutdown pin 10 exceeds the limit value adjustable with P1, the control IC switches off immediately, restarting after a short duration. The reason for this is usually excessive current at the secondary side of the power transformer, either caused by a short-circuit, or an overload to the output. The load and the circuit itself are likewise protected from overvoltage at the Vo output. The SG3525 switches off at Vo > 15 V. Note: Both protection circuits are ineffective if the slider of P1 is adjusted to Gnd potential.

Synchronous rectifier

A rectifier made with fast recovery diodes loses up to 17 W at 18 A output current. Even with a 30 A / 45 V Schottky diode, the losses are still 12 W. This is the supply's greatest single loss, exceeding the losses at the mains rectifier, power switches, transformers, and output choke combined.

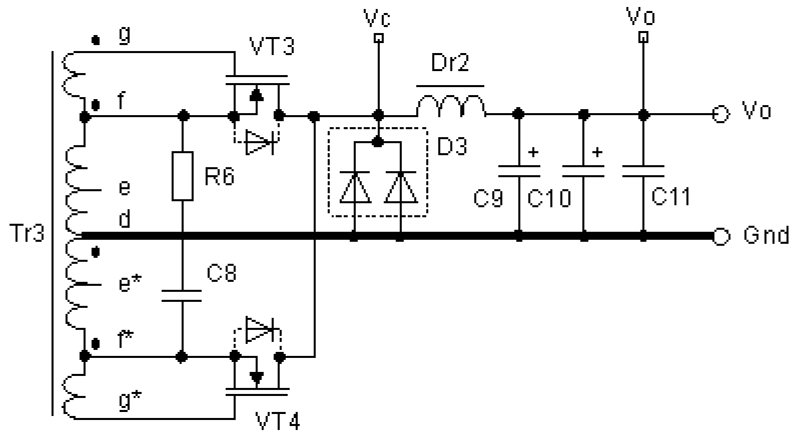
An improvement brings here a semi synchronous rectifier with two low impedance power FETs. FETs with a low Ron of e.g. 15 mOhm have only a voltage drop of 0,3 V at 18 A during the conduction phase. Good Schottky diodes are rated at 0,6 V. In the literature, however, with push-pull topology, such circuits are advised against because the choke Dr2's current will flow backwards through the FETs' parasitic body diodes while they're in the 'off' state. High switching losses result due to the storage charge of the body diodes, which has to be removed first before/during the transition to the normal operation. This loss destroys the benefits achieved during the conduction phase.

The following circuit avoids this disadvantage, since the body diodes never conduct. Schottky free-wheeling diode D3 has a substantially smaller forward voltage Uf than the FET's body diode, and so takes over choke Dr2's current. D3 has minimal storage charge, so switching is extremely fast and losses are low. As a test, D3 was removed. The FETs' heat sink warmed up thereupon by around +10

°C, even though the body diode of the IRFZ44 used has a very good trr (reverse recovery time) of 47 ns.

With a typical duty cycle of 57 % the loss in the two FETs together is 3.6 W. The free wheeling diode D3 conducts for the remaining time, dissipating 4.6 W. Losses below 8.2 W can only be achieved by replacing free-wheeling diode D3 with a FET. Since driving this FET is more complex than for VT3 and VT4, I did without this. A second complication is that with mains undervoltage or high output current, the switch-on time of VT3/4 rises, but not the switch-on time of D3.

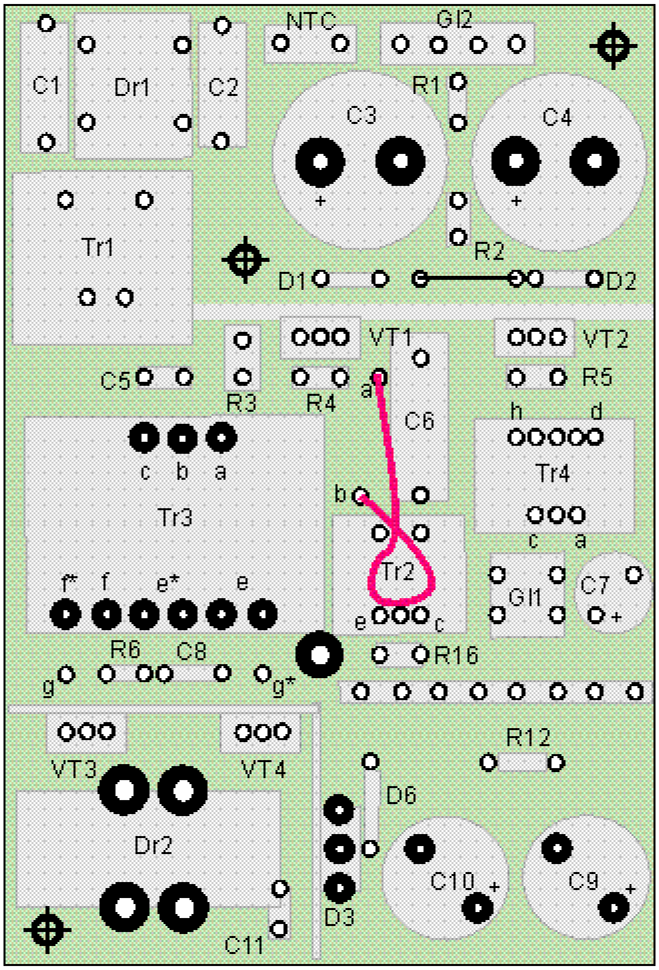
Fig. 4: Synchronous rectifier

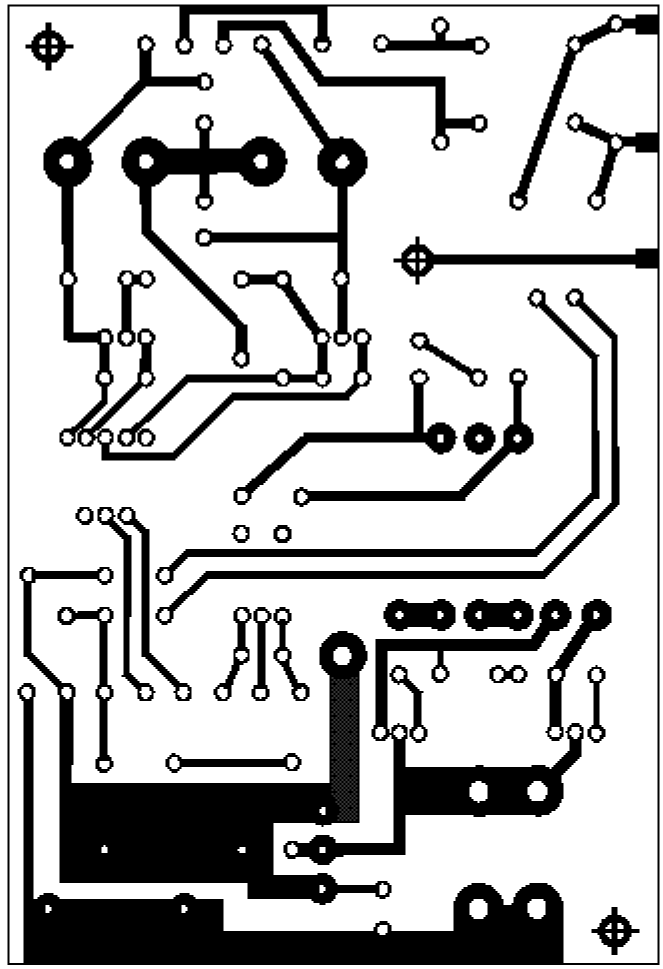


Construction and alignment

The power supply uses an 82 x 122 mm glass-epoxy circuit board. Other materials are not suitable, as the board must be able to carry relatively heavy components and realize high-current copper tracks. The components for regulation and monitoring are mounted on a small strip board. Sorry, but I was too lazy to design a PCB layout for this circuit part.

Fig.5: PCB layout (1:1) and assembly





For the interconnection of the components for regulation and monitoring a 40 x 45 mm small strip-board is sufficient. The copper tracks (pink) are to be removed in the indicated places. A wood or a metal drill with a diameter from 3 to 4 mm is suited to this task. Jumpers are drawn as broken lines. (They're easily forgotten during assembly! The same applies to the horizontal ground-potential bar within the upper area of the strip-board that distributes Gnd potential onto the vertical copper tracks.

Fig.6: View of the strip-board soldering side (2:1)

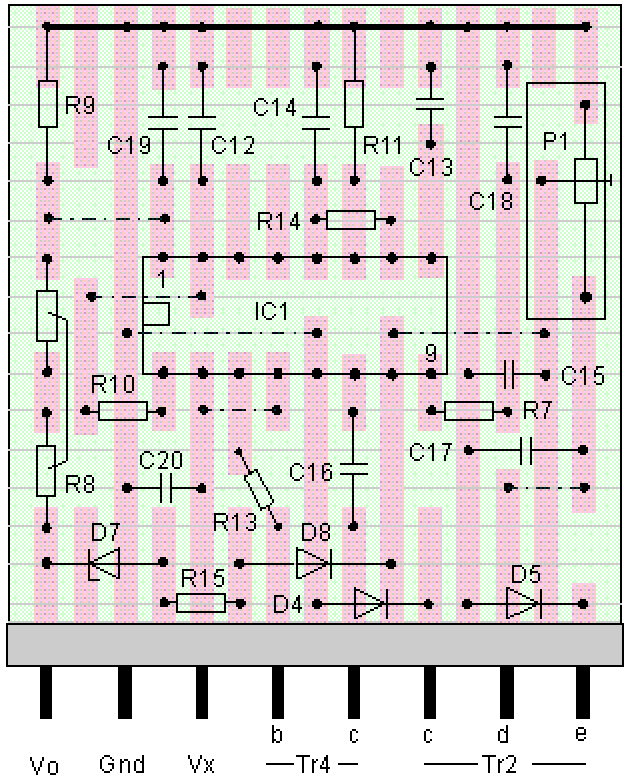
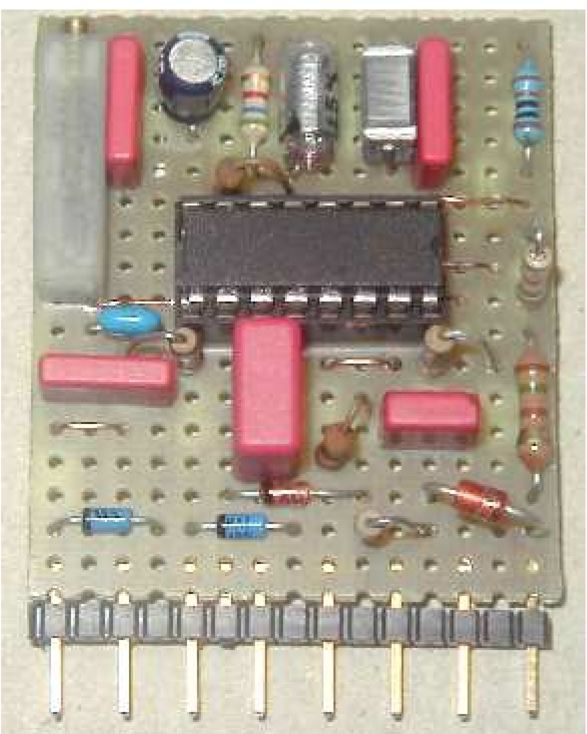


Fig. 7: View of the strip-board component side (2:1)

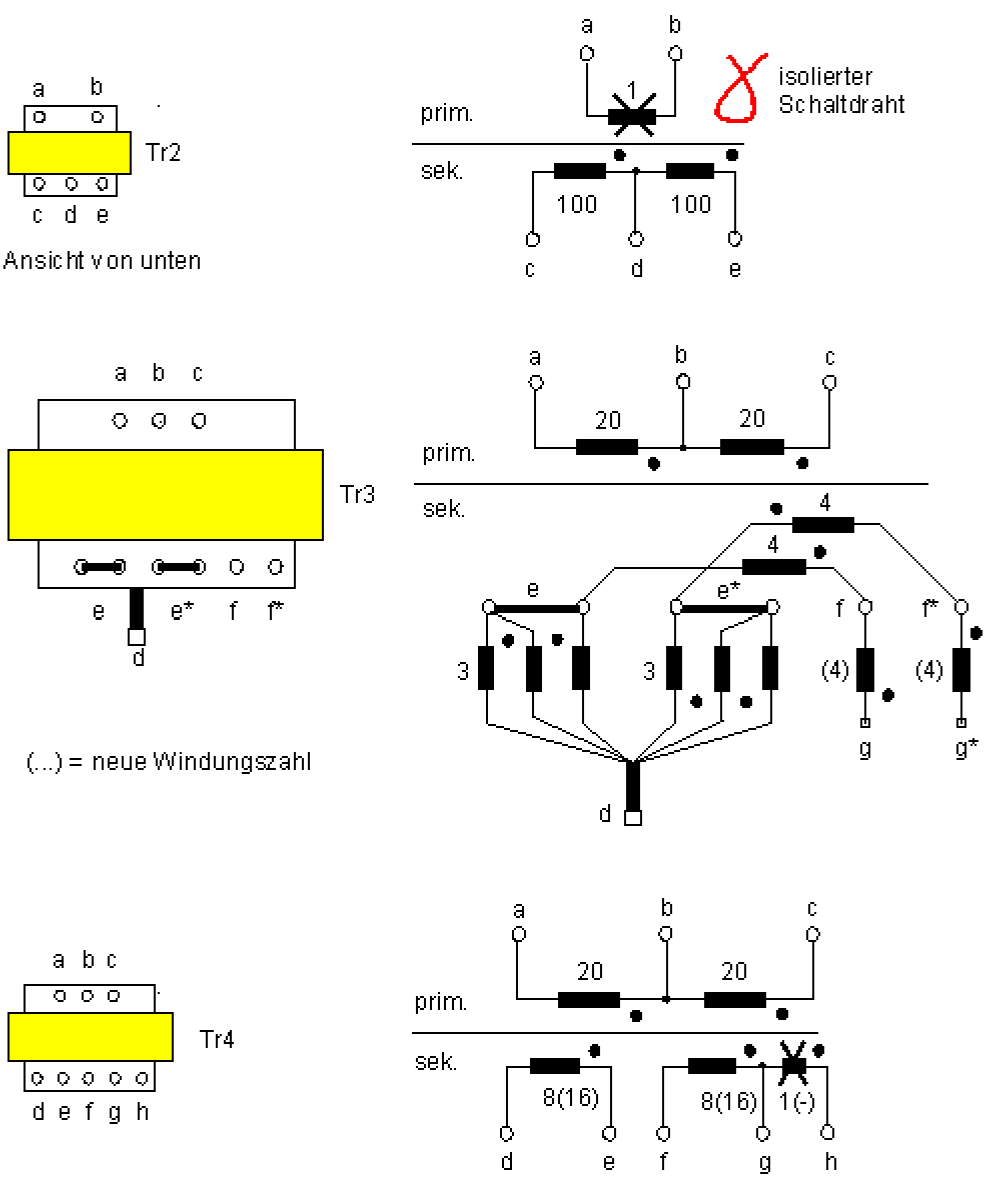


Transformers

The following drawing shows the transformers stripped from a PC switching power supply. The data were determined as best as possible by measurements, counting turns, and calculations.

Before using the transformers, it must to be confirmed that the size, number of layers, wire size, number of turns and phasing correspond to the specification in the drawing and the photos. If there's any doubt about whether your transformers match these specs, the transformers should not be used.

Fig. 8: PC transformers and modifications

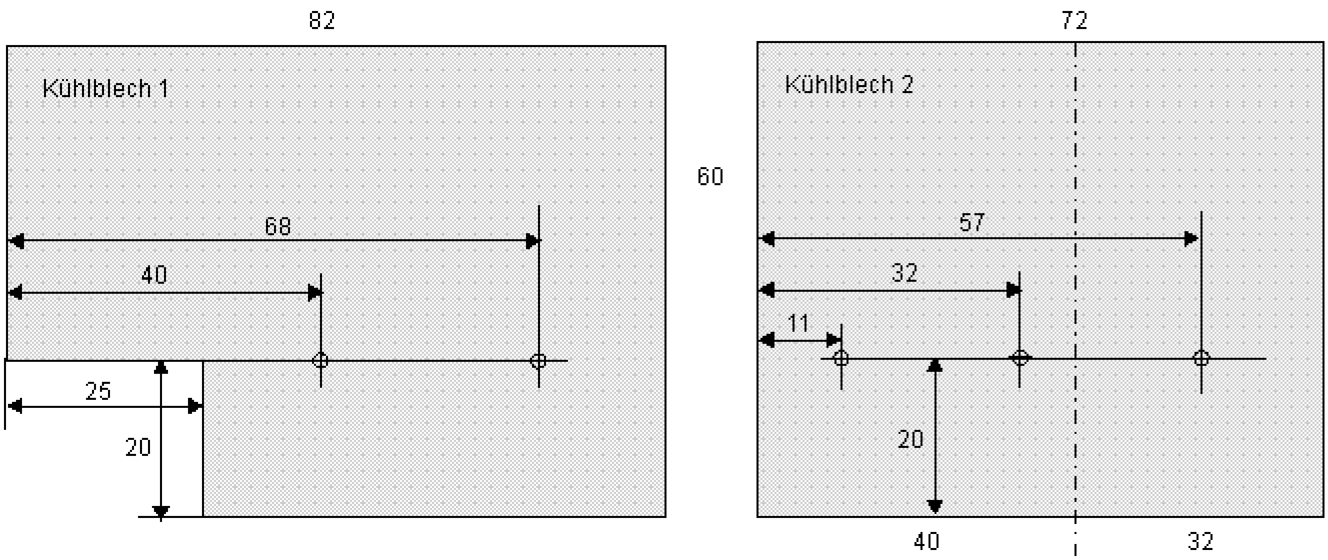


Heat sinks

The heat sinks are nothing special, manufactured from an approx. 1 mm thick aluminum plate. VT1 and VT2 are to be fastened isolated on the first heat sink. The FETs must not have a electrical connection to each other, or to the heat sink. With proper, professional assembly of the transistors [e.g., insulated from the heatsink], touching the heat sink isn't dangerous. On the secondary side it is somewhat simpler. VT3, VT4 and D3 carry no dangerous voltage, and need thus no isolation. Because of the FETs case and the Schottky diodes case have the same potential, there is no problem with mounting all three components directly onto the second heat sink. Be sure, however, that there's no

electrical connection between the heat sink itself and the power supply housing or electrical components.

Fig.9: Heat sink drawings



Parts list (1)

Resistors, capacitors and semiconductors

Parts No.	Value
R1, 2	120 kOhm, 0,5 W
R3	100 Ohm , 2 W
R4, 5, 9	1 kOhm
R6	10 Ohm, 2 W
R7, 10	10 kOhm
R8	1,5 KOhm + 150 Ohm
R11	5,6 kOhm
R12, 13, 14	47 Ohm
R15, 16	150 Ohm
P1	10 kOhm trimming pot, 10 turns
NTC	Heissleiter, 5 Ohm at 25 °C
C1, 2	0,1 uF 250 Vac
C3, 4	470 uF 200 V, 22 x 36 mm (diam. , H)
C5, 15	2,2 nF
C6	1 uF, 250 Vac
C9, 10	2200 uF, 35 V low ESR, 16 x 34 mm (Diam., H)
C7	100 µF, 35 V
C8, C20	10 nF
C11,12	0,22 µF
C13	10 uF, 25 V

C14	2,2 nF Styroflex
C16	2,2 uF
C17, 18, 19	0,047 uF
D1, 2	PXPR1507 etc. fast 200 V / 1A diode
D3	MBR3045, 30 A / 45 V Schottky diode
D4, 5, 6	BAT 46
D7	Zener diode, 13 V / 0,5 W
D8	1N4148
VT1, 2	IRF730
VT3, 4	IRFZ44N
IC1	SG3525A
Gl1	Rectifier bridge, dual in-line B40C800 DIP
Gl2	Rectifier bridge 400 V / 4 A

Parts list (2)

Transformers, chokes and miscellaneous

Parts No.	Value
Tr1	0,5 W print transformer EE20/10, 15 Vac at 34 mA, 24 x 32 mm (Reichelt/Conrad)
Tr2	16 x 15 x 5 mm (W,H,D)
	1 turn. prim.
	2x 100 turns sec.
Tr3	40 x 35 x 12 mm (W,H,D) e.g. Tokin 25812 or. 25801
	2x 20 turns prim. (L = 7 mH between a <=> c)
	2x (3 + 4) turns sec. (L = 200 uH between d <=> f or d* <=> f*)
	2x 4 turns sec. auxiliary winding for driving VT3/4
Tr4	22 x 19 x 6 mm (W,H,D)
	2x 26 turns. prim.
	2x 16 turns. sec.
Dr1	current compensated 2A mains voltage choke
Dr2	20 uH, T26-106 (yel. / white), 16 turns. 2x 1 mm Cu wires in parallel
	better Magnetics Kool 259-77934-A7, 20 turns. 2x1 mm Cu wires in parallel
Additional mains filter	general purpose 230 V / 2 A
Si	3,15 AT fuse, slow blow
PS	Two pole mains switch
Miscellaneous	PCB, heat sinks, isolation material, heat sink compounder etc.

The grey marked cells indicate the components, which can be scavenged from a PC power supply. The electrical data must be compared before using them, and the indicated modifications have to be

made.

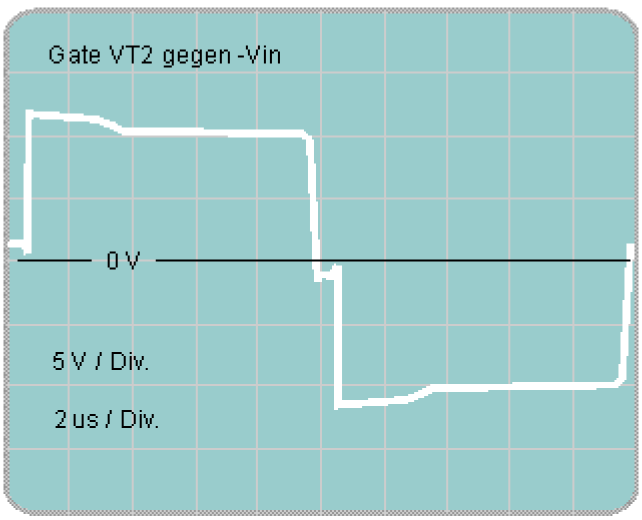
Testing the power supply

I urgently advise against immediate connection to 230 Vac. Testing of the new power supply should take place in several test phases for safety reasons, and for the avoidance of component destruction. The high voltage causes an immediate destruction of the components in the case of an error in the circuit.

Warning: Check temperature of components only if the mains voltage is switched off.

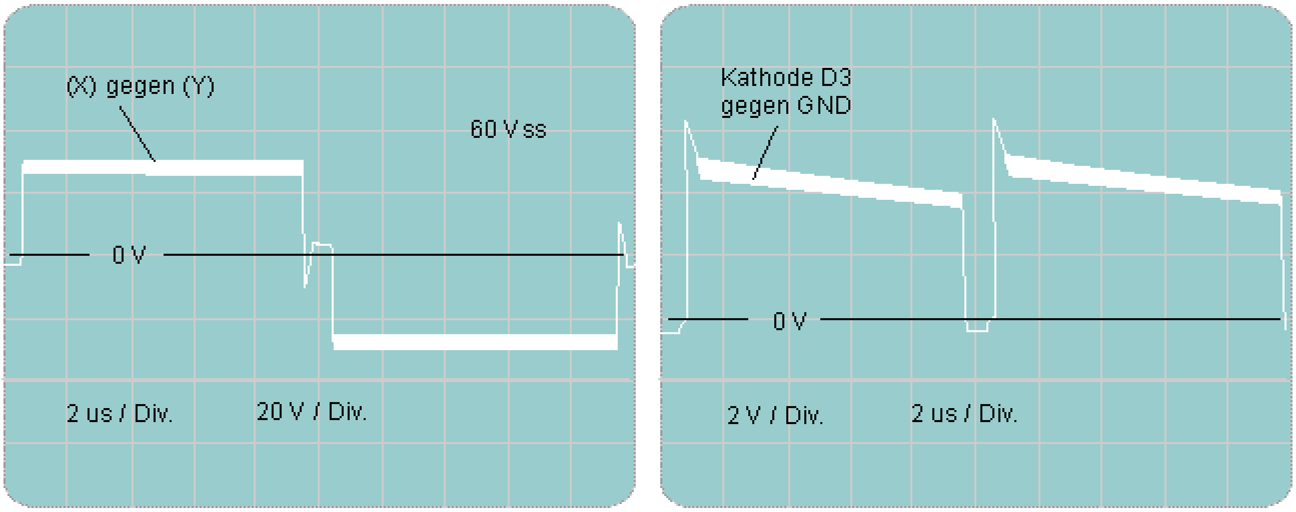
*Phase 1:*The first test applies to the PWM-IC and the power switch control. For running the PWM-IC, connect a 24Vdc lab power supply to Gnd and the positive plate of C7 (Vx). After switching on, the IC generates sharply rising and falling control pulses with maximum pulse duration at the output pins 11 and 14. With an oscilloscope, signals measured at the gate of VT2 (VT1) should look like the one shown in figure 9. It's very important that the signals have the indicated shape, voltage and frequency. Further, the signals at the gates of VT1 and VT2 should be opposite in phase (otherwise, both FETs would conduct at the same time, producing a short-circuit later, when applying supply voltage).

Fig. 9: VT2 (VT1) gate-source voltage



Phase 2: Now, connect three car light bulbs (12 V / 21 W) to the 13,8 V output terminals. A 48 V / 1 A mains transformer feeds the S.M.P.S. via the L1 and N terminal with a galvanically isolated Ac voltage. The + 24 Vdc lab supply is still connected during this test. 60 Vdc at C3 / C4 is in Europe defined as a non-dangerous voltage. At this voltage the switching transistors can start operating, allowing one to perform testing without danger. For measurements with a dual-channel oscilloscope Gnd from the secondary section has to be connected temporarily to the (Y) test point of the primary section with a wire link. The bulbs glow at Vout = 4,3 Vdc if everything is right. Rectification is performed by the FETs body diodes only, because the VT3 and VT4 gate-source voltage is not high enough to switch on the FET. The PWM controller tries to produce 13,8 V at the output at maximum pulse duration / duty cycle. The latter cannot be successful due to the low 60 Vdc input voltage and the present transformer ratio.

Fig. 10: Voltage at test point (X) against (Y) und cathode D3 against Gnd



*<u>Phase 3:</u>*If everything is all right so far, one can proceed with the exciting test at 230 Vac. The laboratory power supply, the 48 V transformer, the measuring instruments and all provisional cable links attached for the test etc. must obviously be removed. The three car bulbs are further needed as a load and for the functional checks. If after applying of the 230 Vac mains voltage the lamps light up brightly, the output voltage is 13.8 V, and no undefined noises or smells are noticeable, one has won the first round. If an error has slipped past the pre-testing undetected, the two switching transistors and copper tracks say “good-bye” with a more or less loud bang. With 5,7 A, the duty cycle D = tp / T = 5 us / 10 us is approximately 50 %.

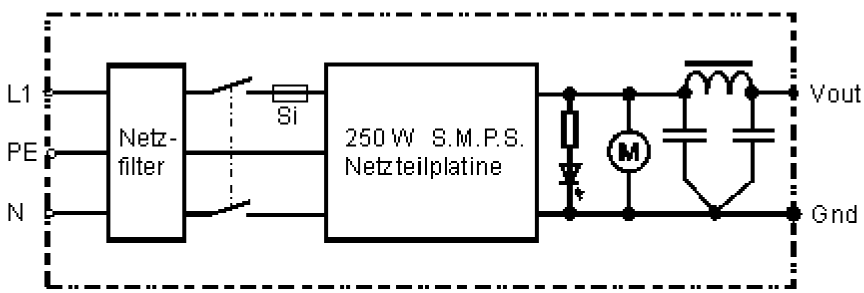
<u>Phase 4:</u> For the following load test a dummy load is needed that can handle up to 300 W. Because such high power resistors are expensive, and not just laying about in the junk box, I instead took a 50 m a ring installation cable (3 x 1.5 mm2) . An individual wire has a resistance of 0.6 ohms and can dissipate the mentioned watts without problems. Depending on interconnection of the three wires, load resistances of 0,6 / 1,2 and 1.8 ohms are realizable. By the ampmeter impedance, including the appropriate measuring wires positioned in series, the resistance value increases by approx. 0.1 ohms. At Vo = 13,8 V the following table indicates the power output Po and the current Io as a function of the loading

Rl [Ohm]	car bulbs	Io [A]	Po [W]
- / -	1x 12 V / 21 W	1,9	26
- / -	2x 12 V / 21 W	3,8	52
- / -	3x 12 V / 21 W	5,7	78
1,8 + 0,1	- / -	7,26	100
1,2 + 0,1	- / -	10,6	146
1,2 + 0,1	2x 12V / 21 W	10,6 + 3,8	198
1,2 + 0,1	3x 12V / 21 W	10,6 + 5,7	224
0,6 + 0,1	- / -	19,7	270

Additional measures for RFI noise reduction

Experience during the PC power supply modification have shown that the on-board filtering is insufficient for amateur radio applications. A pre-fabbed general purpose mains filter and a home made Pi filter direct to the 13,8 V output are used for improved RF noise reduction. To maintain control loop stability, the PI filter is outside the control loop, so its voltage drop isn't eliminated by the supply's regulation. Output voltage changes of several tens of millivolts under load changes have no importance for running a 100 W transceiver. The additional filters have to be mounted inside the S.M.P.S. case very close to the cable inlet and outlet.

Fig. 11: External components for RF noise reduction

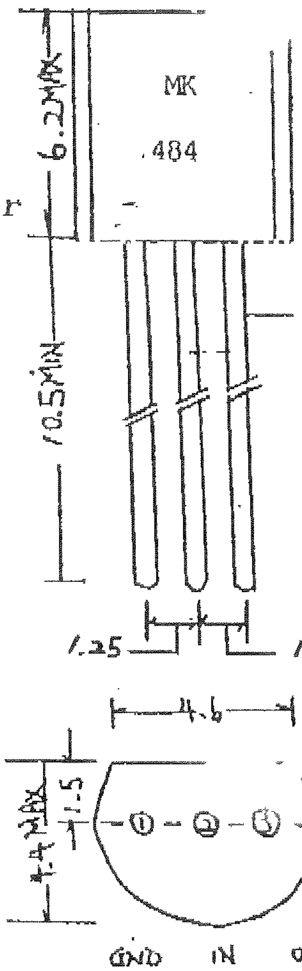


Operation experiences

Up to 10 A continuous output current, or operation with 50 % ESD and 18 A peak current are possible without a fan if sufficient natural air flow is present and the ambient temperature does not exceed 30 °C. A small CPU fan (40 x 40 mm) should be used for more than 10 A continuous current. The heatsink surface is not large enough to keep the FETs junction temperature below the limit value (Tj < 100 °C). With a CPU fan the heat sink temperature remains below 28 °C (Tu = 20 °C). The following table shows the measured and calculated power dissipation Pv of the basic components at 250 W output power.

Abbr.	Parts	Pv [W]
Gl2, Dr1	Mains rectifier and filter	2,5
VT1	Switching transistors	4,0
VT2		4,0
R3 / C5	Snubbers	1,5
Tr3		

High Sensitivity and high quality AM Radio is possible with a few outside components. As special fetures of the circuit include low supply voltage operation, the device is particulary useful in Watch Radio and lighter with Radio.



FEATURES

1. Stably operates with 1.1v
2. Low Drain Current
3. Small and light weight (TO92)
4. Wide AGC Ranging

APPLICATIONS

Watch Radio
Lighter with Radio
Wireless AM-System

ELECTRICAL CHARACTERISTICS

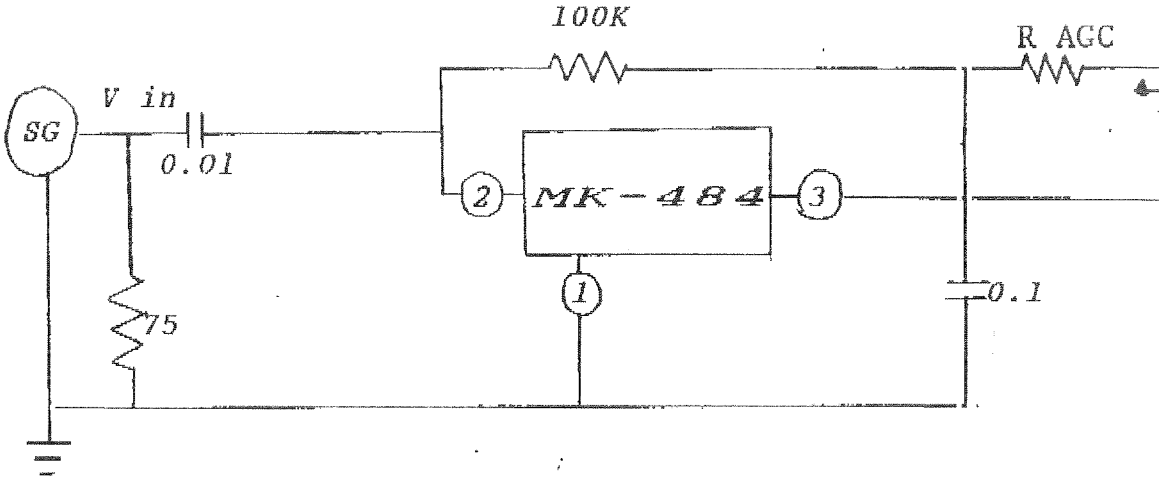
ITEM	SYMBOL	MIN	TYP.	MAX.	UNIT
SUPPLY VOLTAGE	Vcc	1.1	1.4	1.8	V
OUTPUT VOLTAGE (at operation)	VOUT * 1	0.8		1.5	mV
DRAIN CURRENT	Icc		0.3		mA
COVER RANGE	∫ R	150		3,000	KhZ
INPUT RESISTANCE	Zin		4		MΩ
TOTAL HARMONIC DISTORTION			4		
AGC RANGE	AGC	30			dB
POWER GAIN	Gp		70		dB

Vcc = 1.4V, Ragc = 1.5KΩ, =1,000KHZ
Modelation 1,000HZ 40%, Vin - 1mV (r.m.s.)

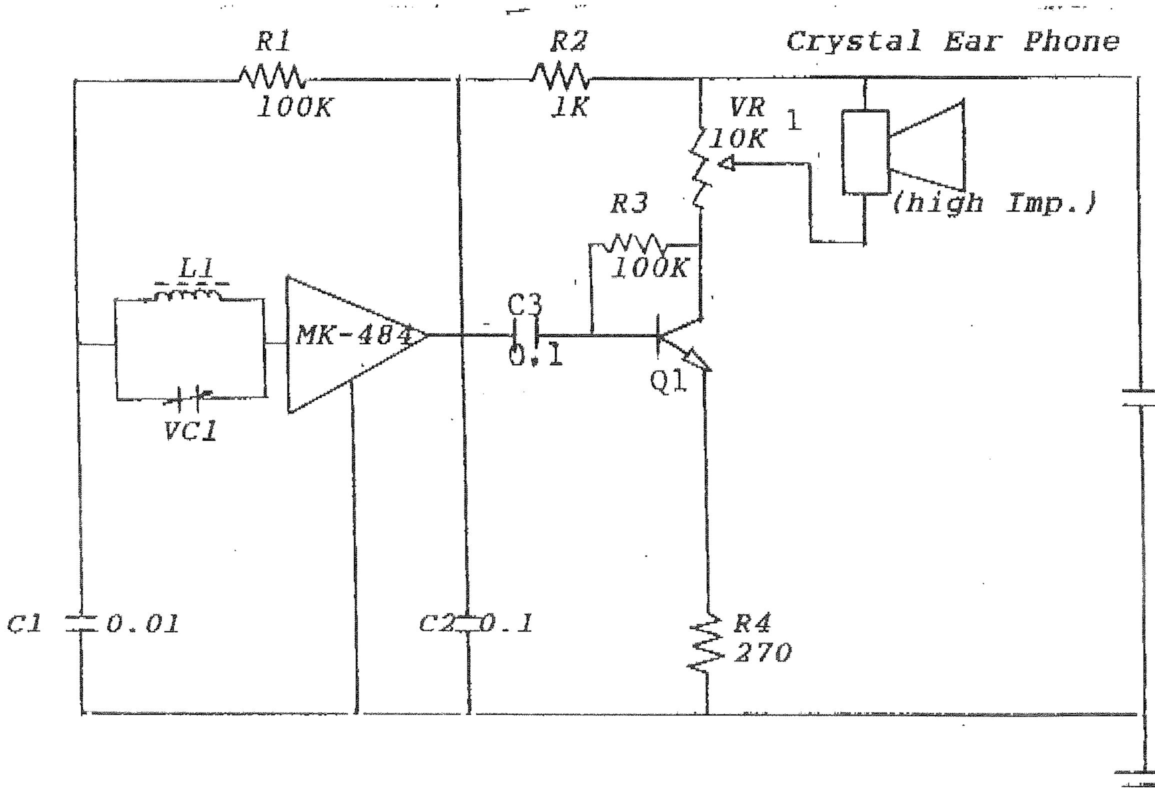
(1) RAGC = 100 - 1.5KΩ

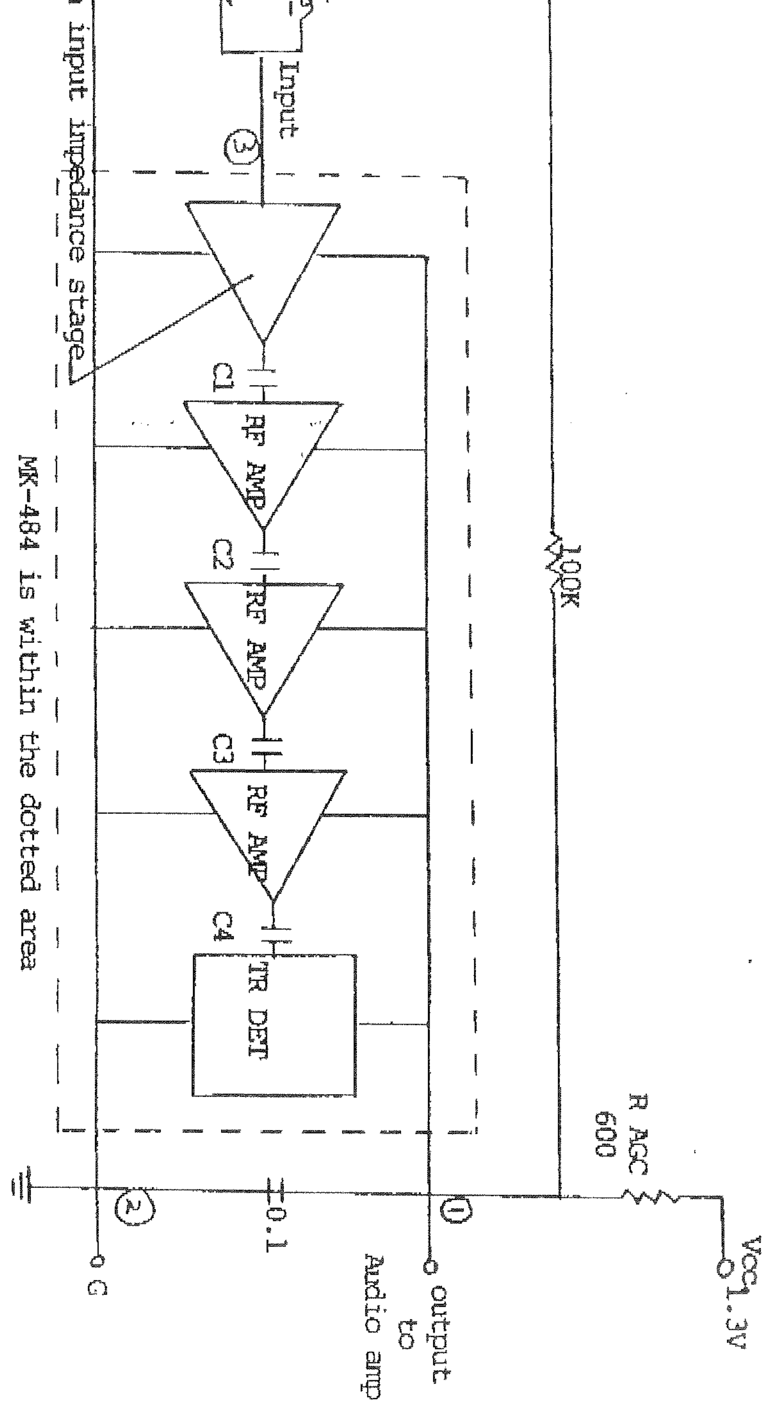
MEASURING CIRCUIT

FOR HIGH IMPEDANCE CIRCUIT



APPLICATION





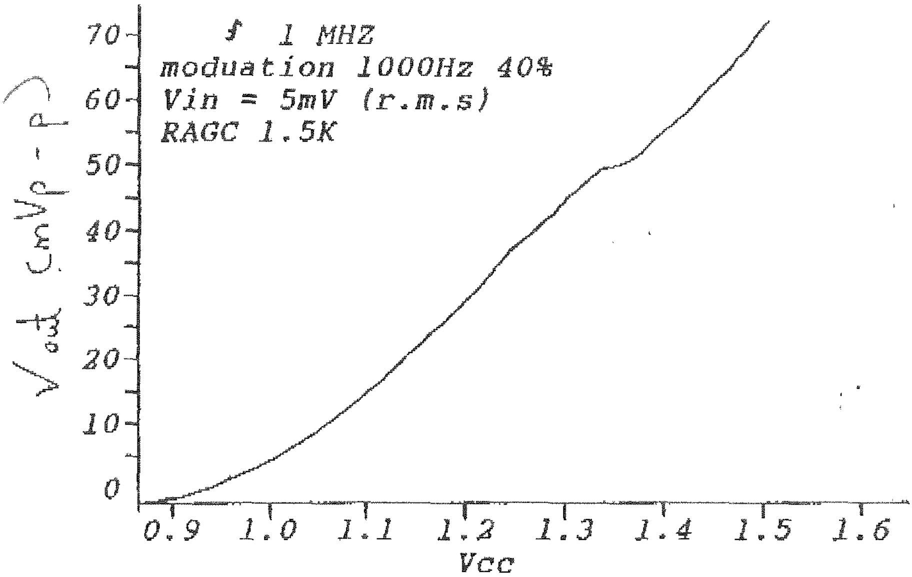
CHARACTERISTIC :

: above 1.1v
put Voltage : 1.0 - 1.5v
ut Current : 0.3mA typ.
4. f : 300K -3MKZ
5. Input Resistance: 4MΩ typ.

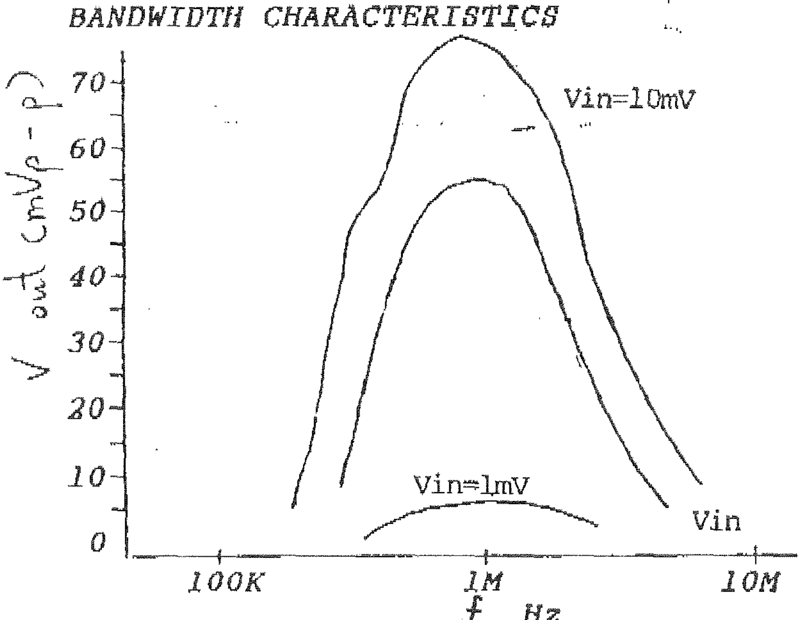
MAXIMUM RATINGS :

OPERATING TEMPERATURE	*SYMBOL*	*RATING*	*UNIT*
OPERATING TEMPERATURE	*Topr*	*-30 - +80*	*°C*
STORAGE TEMPERATURE	*Tstg*	*-40 - +125*	*°C*
SUPPLY VOLTAGE	*Vcc*	*1.5*	*V*

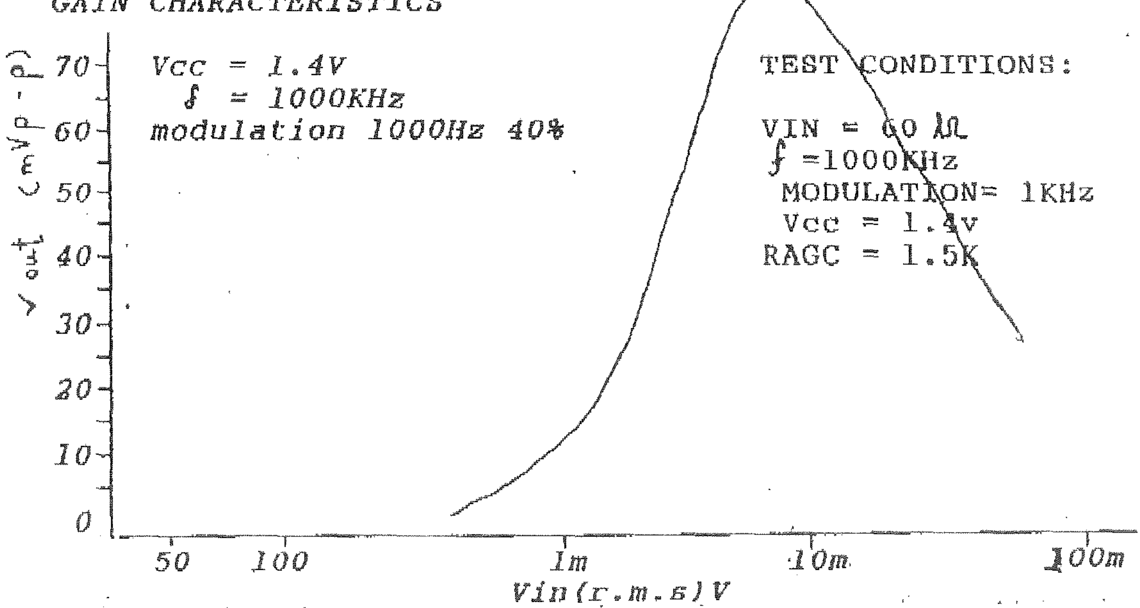
GAIN VARIATION WITH SUPPLY VOLTAGE



BANDWIDTH CHARACTERISTICS



GAIN CHARACTERISTICS



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Aircraft Frequencies

World Wide HF and VHF/UHF Aircraft Communications Listening

What do you need to get started listening to the world of monitoring Aircraft communications?

If you have a good quality VHF/UHF scanning receiver and a HF communications receiver that will tune from about 2mhz thru 30mhz with LSB/USB mode on the HF bands (shortwave radio) then you are all set to join in the excitement of DX'ing HF Aeronautical radio communications.!

If you just stumbled into this site and your looking for a good quality receiver for HF, then check out this page and look for the Sony ICF SW 7600GR. It is highly recommended for tuning the Hf aircraft band frequencies.

To monitor the VHF/UHF frequencies:
You will need a good quality scanner receiver for VHF UHF to monitor aircraft frequency bands over land or within line of sight of major air traffic control centers. You won't have a problem hearing airborn aircraft within your area. Remember that VHF / UHF frequencies are "line of sight". If the aircraft are beyond your horizon, you won't hear them due to their signals being blocked by the earth.
Excellent quality VHF/UHF scanners can be found from ScannerMaster.
Click here to take a look if you're interested! They have all price ranges and models to choose from.

A good outside antenna will also help your receiver to receive the signals much better. See the shortwave antenna projects on this site and build one for HF and also look on the antenna projects page (Antenna Design) on the left menu, for any antenna that can be built for the VHF bands and designed for the aircraft frequencies. Check out the simple projects. You'll save big bucks by doing it yourself! Most are simple to build using material from your local hardware store, Lowes, Home Depot, etc and since you will only be using them on receive only, no special test equipment will be needed. A good HF multi band project can be found here!

Who, what and when!

Aircraft communications from over the oceans can be very boring at times or very exciting! Along with the use of satellite communications, commercial and military aircraft use either the VHF/UHF frequencies when over or near land and switch to worldwide or nearly so, HF frequencies when over oceans and far beyond line of sight with land based ground stations.

They are not active all the time and are not always on the frequency that you are, so be patient and tune around the frequencies listed on this page.

The aeronautical voice communications stations and frequencies listed in the tables below are available to and utilized by the U.S. FAA Air Route Traffic Control Centers (ARTCCs) for air traffic control purposes.

The frequencies in use will depend upon the time of day or night and conditions which affect radio wave propagation especially on HF frequencies. Voice communications are handled on a single channel simplex basis (i.e., with the aircraft and the ground station using the same frequency for transmission and reception) unless otherwise noted in remarks.

The stations will remain on continuous watch for aircraft within their communication areas, and when practicable, will transfer this watch to another station when the aircraft reaches the limit of the communications area.

Stations listed below which are designated "FAA" are operated by the U.S. FAA Flight Service Stations. Stations designated "ARINC" are operated by Aeronautical Radio, Incorporated.
Sections or frequencies highlighted in Green in the table below are usually long range and are usually transmitted in USB mode.
Other frequencies (VHF/UHF) are AM.

STATION	RADIO	TRANSMITTING	REMARKS

AND OPERATING AGENCY	CALL	FREQUENCIES	Freqencies with decimal point are (Mhz) Others are khz
HONOLULU (FAA)	Honolulu Radio	122.6 122.2 **#121.5 MHz**	#Emergency. Frequency 122.1 also available for receiving only.
	Volmet	2863 6679 8828 13282 kHz	Broadcasts at H+00-05 and H+30-35; Aerodrome Forecasts, Honolulu, Hilo, Agana, Honolulu. SIGMET. Hourly Report, Honolulu, Hilo, Kahului, Agana, Honolulu.
			Broadcasts at H+05-10 and H+35-40; Hourly Reports, San Francisco, Los Angeles, Seattle, Portland, Sacramento, Ontario, Las Vegas. SIGMET. Aerodrome Forecasts, San Francisco, Seattle, Los Angeles.
			Broadcasts at H+25-30 and H+55-60; Hourly Reports, Anchorage, Elmendorf, Fairbanks, Cold Bay, King Salmon, Vancouver. SIGMET. Aerodrome Forecasts, Anchorage, Fairbanks, Cold Bay, Vancouver.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
MIAMI (FAA)	Miami Radio	126.7 118.4 126.9 122.2 122.4 122.75 123.65 127.9 MHz	Local and Short Range.
		#121.5MHz	#Emergency.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
NEW YORK (FAA)	New York Radio (Volmet)	3485* 6604 10051 13270* kHz	*3485 Volmet broadcasts from 1 hour after sunset to 1 hour before sunrise.
			*13270 Volmet broadcasts from 1 hour before sunrise to 1 hour after sunset.
			Broadcasts at H+00-05; Aerodrome Forecasts, Detroit, Chicago, Cleveland. Hourly Reports, Detroit, Chicago, Cleveland, Niagara Falls, Milwaukee, Indianapolis.
			Broadcasts at H+05-10; SIGMET, (Oceanic-New York). Aerodrome Forecasts, Bangor, Pittsburgh, Charlotte. Hourly Reports, Bangor, Pittsburgh, Windsor Locks, St. Louis, Charlotte, Minneapolis.
			Broadcasts at H+10-15; Aerodrome Forecasts, New York, Newark, Boston. Hourly reports, New York, Newark, Boston, Baltimore, Philadelphia, Washington.
			Broadcasts at H+15-20; SIGMET (Oceanic-Miami/San Juan). Aerodrome Forecasts, Bermuda, Miami, Atlanta. Hourly Reports, Bermuda, Miami, Nassau, Freeport, Tampa,West Palm Beach, Atlanta.
			Broadcasts at H+30-35; Aerodrome Forecasts, Niagara Falls, Milwaukee, Indianapolis. Hourly Reports Detroit, Chicago, Cleveland, Niagara Falls, Milwaukee, Indianapolis.
			Broadcasts at H+35-40; SIGMET (Oceanic-New York). Aerodrome Forecasts, Windsor Locks, St. Louis. Hourly Reports, Bangor, Pittsburgh, Windsor Locks, St. Louis, Charlotte. Minneapolis.
			Broadcasts at H+40-45; Aerodrome Forecasts, Baltimore, Philadelphia, Washington. Hourly Reports, New York, Newark, Boston, Baltimore, Philadelphia, Washington.
			Juan). Aerodrome Forecasts, Nassau, Freeport. Hourly Reports, Bermuda, Miami, Nassau, Freeport, Tampa, West Palm Beach, Atlanta.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
NEW YORK (ARINC)	New York	3016 5598 8906 13306 17946 21964 kHz	North Atlantic Family A Network.
		2962 6628 8825 11309	North Atlantic Family E Network.

		13354 17952 kHz	
		2887 3455 5550 6577 8846 11396 kHz	Caribbean Family A Network.
		5520 6586 8918 11330 13297 17907 kHz	Caribbean Family B Network.
		3494 6640 8933 11342 13330 17925 kHz	Long Distance Operations Control (LDOC) Service (phone-patch). Communications are limited to operational control matters only. Public correspondence (personal messages) to/from crew or passengers can not be accepted. NOTE: New York ARINC can also provide HF communications over South America on these LDOC frequencies through their remote site located in Santa Cruz, Bolivia.
		129.90 MHz	Extended range VHF. Coverage area includes Canadian Maritime Provinces, and oceanic routes to Bermuda and the Caribbean, from Boston, New York and Washington areas to approximately 250 nautical miles from the east coast.
		130.7 MHz	Extended range VHF. Full period service is provided within most of the Gulf of Mexico. Also on routes between Miami and San Juan to a distance of approximately 250 nautical miles from the Florida coast and within approximately 250 nautical miles of San Juan. NOTE: New York ARINC also provides VHF communications over the Northern two-thirds of Mexico on 130.7 MHz for FAR Part 121.99 compliance.
		436623* 631-244-2492	Aircraft operating within the New York Oceanic FIR. *NOTE: This satellite Voice Air/Ground calling number is available to call ARINC and will be recognized and converted by all Ground Earth Station (GES) service providers to the appropriate Public Service Telephone Network (PTSN) or direct dial number for this communications center.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
SAN FRANCISCO (ARINC)	San Francisco	3413 3452 5574 6673 8843 10057 13354 kHz	Central East Pacific One Network
		2869 5547 11282 13288 21964 kHz	Central East Pacific Two Network
		2998 4666 6532 8903 11384 13300 17904 21985 kHz	Central West Pacific Network
		3467 5643 8867 13261 17904 kHz	South Pacific Network
		2932 5628 5667 6655 8915 8951 10048 11330 13273 13339	North Pacific Network

		17946 21925 kHz	
		3494 6640 11342 13348 17925 21964	Long Distance Operations Control (LDOC) Service (phone-patch). Communications are limited to operational control matters only. Public correspondence (personal messages)to/from crew or passengers can not be accepted. NOTE: San Francisco ARINC can also provide HF communications along the polar routes on these LDOC frequencies through their remote site located at Barrow, Alaska.
		131.95 MHz	Extended range VHF. Coverage area includes area surrounding the Hawaiian Islands and along the tracks from HNL to the mainland. Coverage extends out approximately 250NM from Hawaii and from the West coast.
		129.40 MHz	For en route communications for aircraft operating on Seattle/Anchorage/Routes.
		436625* 925-371-3920	Aircraft operating within the Oakland and Anchorage Oceanic FIRs. *Note: This satellite Voice Air/Ground calling number is available to call ARINC and will be recognized and converted by all Ground Earth Station (GES) service providers to the appropriate Public Service Telephone Network (PTSN) or direct dial number for this communications center.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
OAKLAND (FAA)	Oakland Radio	122.5 122.2 #121.5 MHz	#Emergency.
STATION AND OPERATING AGENCY	**RADIO CALL**	**TRANSMITTING FREQUENCIES**	**REMARKS**
SAN JUAN P.R. (FAA)	San Juan Radio	#121.5 122.2 126.7 123.65 #243.0 255.4 114.0 113.5 108.2 108.6 109.0 110.6 MHz	Unscheduled broadcasts H+00, H+15, H+30 and H+45 as appropriate, for Weather and Military Activity Advisories, on 110.6, 109.0, 108.6, 108.2, 113.5, and 114.0 MHz. #Emergency. For frequencies 114.0, 113.5, 108.2 and 109.0 MHz use 122.1 MHz for transmissions to San Juan Radio. For frequency 108.6 use 123.6 MHz.

Source of table information: *The FAA (Federal Aviation Administration)* Sept, 2006

AirCraft Frequency listing by State! Click Here! (You will leave this website)

Military Long Range Aeronautical Frequencies
U.S. ARMED FORCES GLOBAL HIGH FREQUENCY SYSTEM IS NOW CALLED
The High Frequency Global Communications System (HF-GCS).

The High Frequency Global Communications System is a network ofsingle sidebandshortwavetransmitters of the United States Air Force which is used to communicate with aircraft in flight, ground stations and some United States Navy surface assets. All worldwide receiving and transmitting sites in the HF-GCS system are remotely controlled fromAndrews AFB.

PUBLISHED FREQUENCY LISTING - HFGCS stations operate on “core" frequencies to provide increased "Global" coverage. The published frequency listing does not reflect complete system frequency authorizations. These published frequencies will be used for initial contact, EAM broadcasts, and short-term C2 phone patch and message delivery. Other extended or special services will be moved to each station’s available "discrete" frequencies.

You may hear highly encrypted or coded voice transmissions at times that make no sense whatsoever. Just be patient. Military and national security at work!

HF-GCS stations tend to operate in the aviation bands clustered around 5, 8 and 11/12 MHz, although other frequencies are in use.

The primary HF-GCS voice frequencies are **4724.0 KHz, 6739.0 KHz, 8992.0 KHz, 11175.0 KHz, 13200.0 KHz and 15016.0 KHz.**
Primary HFGCS Frequencies 24 Hours: **8992 and 11175**
Back up HFGCS Frequencies Day: 13200 15016
Back up HFGCS Frequencies Night: 4724 6739

In addition to the HF-GCS, U.S. aircraft frequently useMilitary Affiliate Radio System (MARS) HF stations (13927.0 KHz) and Canadian Forces HF stations (11232.0 KHz) to relay messages.

Although transmissions are often single sideband, the use of theALE , a type of digital transmission mode, is more and more common.

HF-GCS complements the use of satellite communications, and digital modes between aircraft and ground stations.

Stations of the HF-GCS Network

Andersen Global, Andersen Air Force Base, Guam Island

Andrews Global, Andrews Air Force Base, Maryland USA

Ascension Global, RAF Ascension Island, Atlantic Ocean

Croughton Global, RAF Croughton, United Kingdom

Diego Garcia Global, Diego GarciaNaval Station, Indian Ocean

Elmendorf Global, Elmendorf Air Force Base, Alaska

Hickam Global, Hickam Air Force Base, Hawaii

Keflavík Global, Keflavík NAS, Iceland

Lajes Global, Lajes Air Base, Azores

McClellan Global (aka West Coast Global), McClellan Air Force Base, California

Offutt Global, Offutt AFB, Nebraska

Puerto Rico Global,Salinas, Puerto Rico

Sigonella Global, Naval Air Station Sigonella, Sicily, Italy

Yokota Global, Yokota Air Base, Japan

Closed Stations

Thule AFB,Greenland USB Voice

**The table below lists some common frequencies presenty in use.
Remember to tune around these frequencies also.
(All frequencies below in KHz. To convert to mhz, count from right hand side of number 3 places to left and add decimal)**

**USAF Bases such as Andrews, Edwards, McClellan,
Offutt, Ascension, Hickam, Thule, Elmendorf, etc.
can be heard with worldwide phone patches, Emergency Action
Messages, general traffic, etc on or near these frequencies and in the
table below:**

4742, 6712, 6739, 8992, 11175, 11244, 13200, 15016

Freq-USB	Description or location
4.7090	Sigonella
4.7240	Andrews, Ascension, Elmendorf, Guam, Hickam, Lejes, Offutt, Salinas, Thule, Yokota
6.7120	Andrews, Ascension, Guam, Lajes
6.7240	Sigonella
6.7390	Ascension, Elmendorf, Guam, Hickam, Salinas, Offutt, Thule, Yokota
8.9920	Andrews, Ascension, Elmendorf, Guam, Hickam, Offutt, Salinas, Thule, Yokota
9.0070	Sigonella
9.0250	Lejes
10.7800	AF Eastern Test Range (Backup for Ascension), Cape Canaveral, Antigua, Ascension, Maui
11.1750	Andrews, Ascension, Elmendorf, Guam, Hickam, Salinas, Offutt, Thule, Yokota
11.1810	Lajes
11.2710	Andrews, Ascension, Elmendorf, Guam, Hickam, Lejes, Offutt, Salinas, Thule, Yokota
13.2120	Lajes
15.0160	Andrews, Ascension, Elmendorf, Guam, Hickam, Lajes, Offutt, Salinas, Thule, Yokota
15.0380	Sigonella
20.3900	AF Eastern Test Range (Backup for Ascension), Cape Canaveral, Antigua, Ascension, Maui

Aeronautical Mobile HF Bands (Khz) Commercial Aircraft

2850-3155 kHz	**6525-6765khz**
3400-3500	**8815-9040**
4650-4750	**10005-10100**
5450-5730	**13200-13360**
	15010-15100

Note: Military aircraft can be heard on some of these bands.

Disclaimers:
NOTICE AND WARNING!:
Frequencies and modes listed here are considered accurate but are subject to change.
We are not responsible for your use of these frequencies.
This information is for entertainment and educational purposes only.

Despite popular opinion, listening to and/or repeating any conversation not intended as a general broadcast TO THE PUBLIC over the airwaves is ILLEGAL IN SOME COUNTIRES! This article is presented for information and educational purposes only and therefore in no way can be construed by anyone as an attempt to aid and abet another person to break any laws or contravene any Act or Regulation made by any country.
Check your local rules and regulations!

We welcome any corrections you may have to these frequencies!
Email us n4ujw at hamuniverse.com

Installing the X-Lock-3 in the Drake TR-7

Pete Juliano, N6QW radioguy90@hotmail.com

I have had excellent success in the use of the Cumbria Designs X-Lock products. The first installation was in a Ten Tec Corsair I which employed the X- Lock-2 and that was done in late 2011. I have since sold the Corsair and the next candidate was a Drake TR-7 where I simply moved the X-Lock-2 from the Corsair to the TR-7. That second install too was successful. The Cumbria Designs website featured an X-Lock-2 installation in TR-7, which was done by Ron, WD8SBB. In addition I also found an Internet reference to a similar X-Lock-2 installation by Marinos, SV9RDU. So between the two articles much of the ground had been plowed. I used the SV9RDU interface design from the X-Lock to the TR-7, which differs slightly from that of WD8SBB.

I was so pleased with the TR-7/X-Lock-2 combination that I purchased another TR-7 and the newest version, the X-Lock-3. The purpose of this short paper is to describe what is needed to install the X-Lock-3 in the TR-7. There is a physical difference in the size of the PC Boards which requires adapting the X-Lock-3 boards so that two convenient mounting holes on the underside of the TR-7 chassis can be used to anchor the PC-Board.

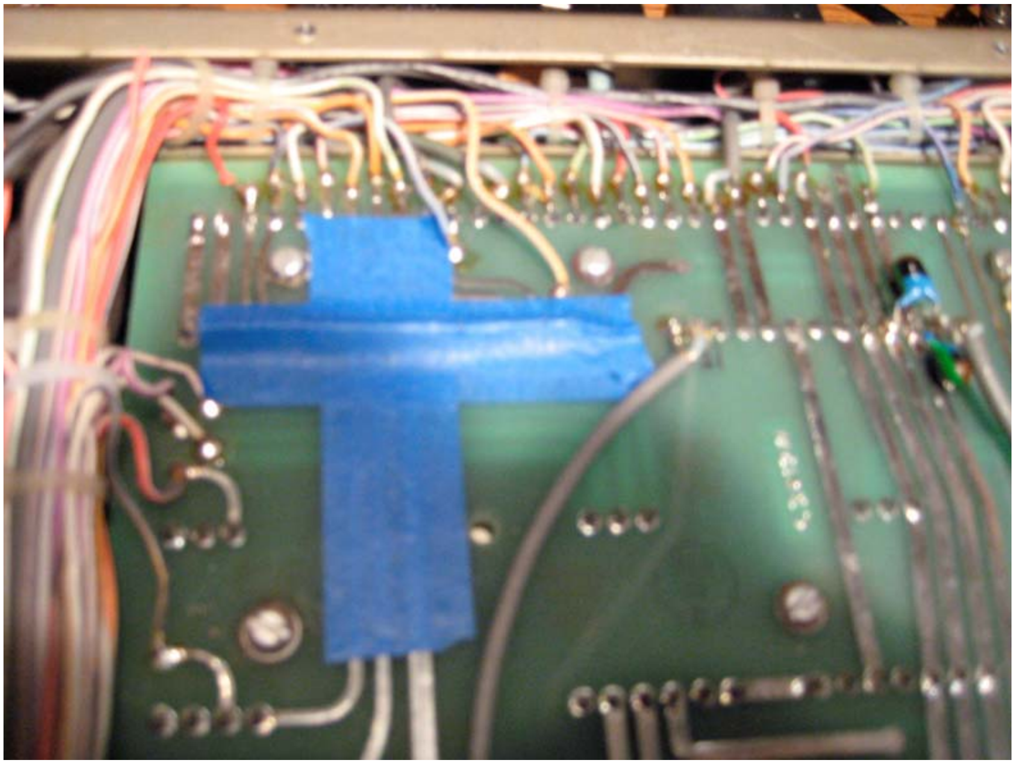
As luck would have it, the mounting holes in the X-Lock-2 board have the same exact spacing as the two screws which anchor the TR-7 Motherboard to the daughter board cage assembly. In the first TR-7 install I simply found longer 4-40 screws and used a 6-32 nut as a spacer and called it installed. Mario used a similar approach and modified some ring type crimp on connectors, which were bent at a right angle. The ring part is screwed down on the board using the original 4-40 screws and the vertical portions are fitted into two of the four mounting hole and soldered in place. Ron mounted his board in another location.

But alas the holes in the X-Lock-3 do not align with the mounting holes in the Motherboard. So at first I thought I would need to use the SV9RDU approach. However in my approach I used #4 solder lugs, which were bent in a “Z” shape so that the large hole is fastened to the chassis using the original 4-40 screws. By using ¼ inch long 2-56 bolts and nuts passed through the smaller hole this arrangement now attaches the PC Board to the TR-7. I was very pleased that it resulted in a very solid mechanical

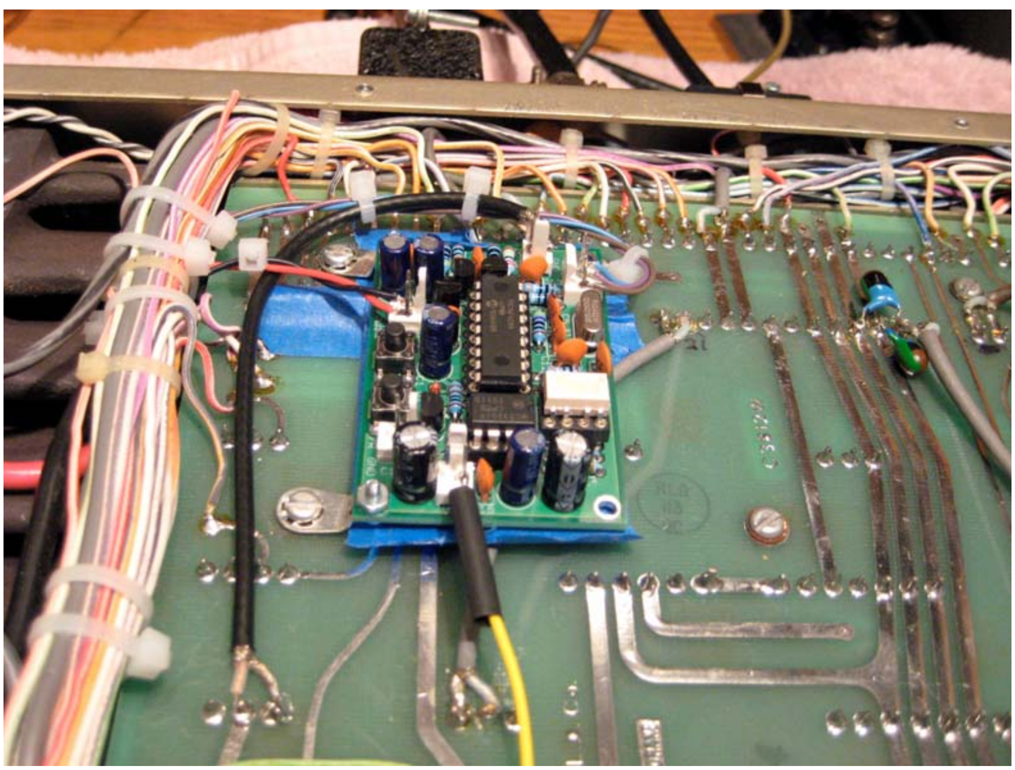
installation. For the tri-color LED I reversed the color so that RED is lock, versus the Green, and installed the LED in the holder where it normally would have the “Fixed light”. I installed a 3-pin header on the end of the cable that connects with the LED and installed a 3-pin plug on the LED. This is so if I have to make any adjustments to the X-Lock-3 I can simply unplug it from the end of the cable and plug it into the circuit board.

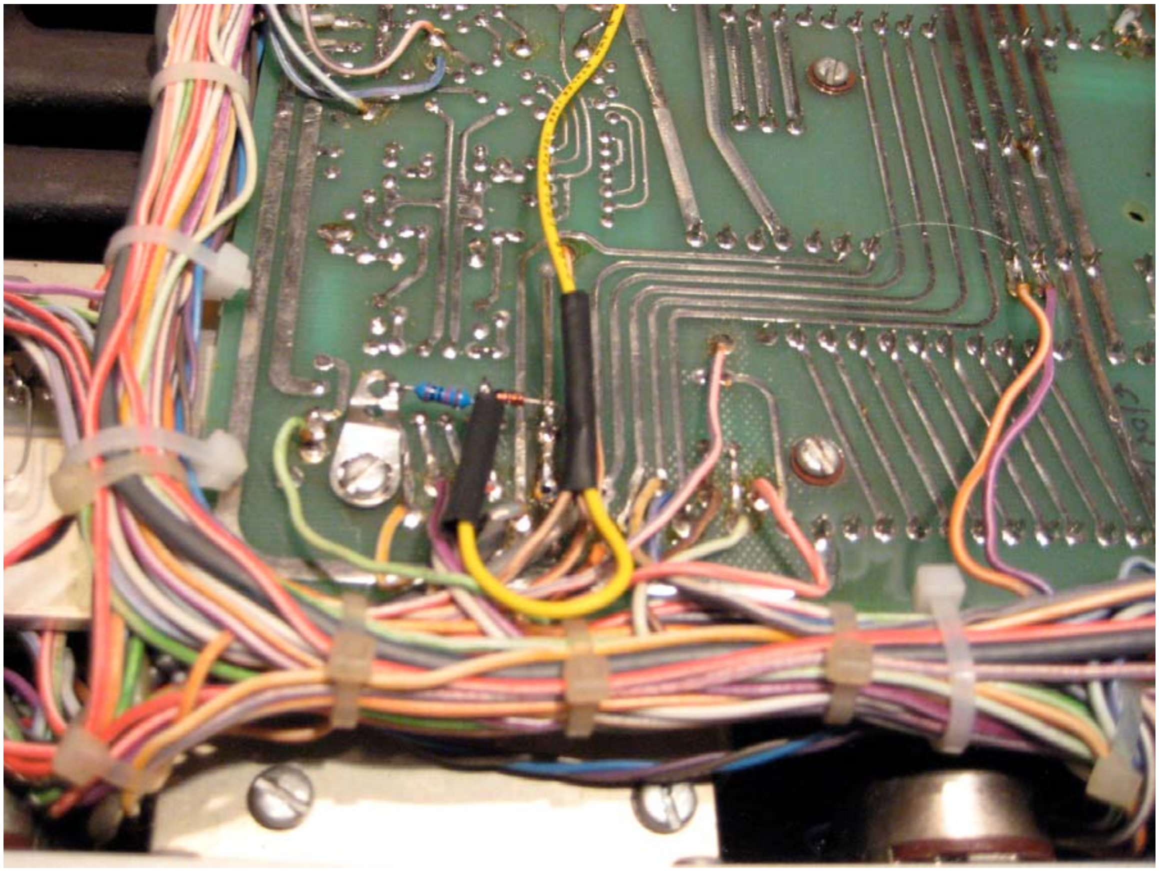
Shown below are the details of the installation.

The #4 solder lug is bent into a “Z” shape using a pair of needle nose pliers. For attachment to the PC board, ¼ inch long 2-56 screws are used. This forms a very stout mechanical connection.



I used 3M masking tape to provide a barrier so the PC Board would not short to the Motherboard traces.





As a final comment on the effectiveness of this addition, I noted that when using PTT that the “Lock” light would flicker briefly upon the “break” action of the relay. The TR-7 display would not change frequency but there was that brief “flicker.” I put a frequency counter on the PTO and observed that there was a brief change of about 80 Hz upon the “Break” action. This same situation is observed on both of my TR-7’s and was confirmed by Ron, WD8SSB on his TR-7 that has been fitted with an X-Lock-2. So this must be a common issue with the TR-7’s.

I also noted that the same condition (the flicker) exists with VOX that has been set up for a short VOX time. If however one lengthens the VOX delay then no flicker is observed and audibly the TR Relay sounds like a “soft break” versus a “clank sound” such as you would have with a quick VOX time constant. I am only guessing but with a longer delay on break there is some sort of exponential decay of the voltage being applied to the TR Relay. At first I thought there was a problem with the “snubbing diode”, a 1N4005 placed across the relay coil. But that is not the case since it is evident on at least three TR-7’s

I contacted Ron Taylor, G4GXO, the designer of the X-lock and he affirmed that any time the X-lock detects a frequency change the ‘wheels are put in motion” to correct for that frequency. So that is a bonus with the device that it is “on guard” to correct for any frequency deviation, even that caused by TR relays.

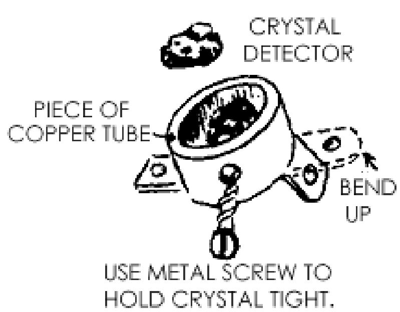
As a test of the X-Lock-3 capabilities I put the TR-7 on a specific frequency at 7:00PM one evening and left the radio powered on all night. The next morning at 7:00 AM I checked the TR-7 and it was on the same frequency as the evening before. I had run the same test with the other TR-7 and the X-Lock-2 and it was the same result. So the X-Lock is a great addition to the venerable TR-7 transceiver.

The crystal radio page

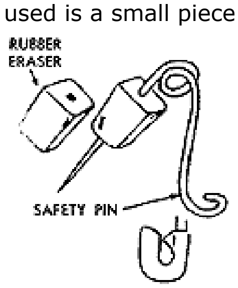
A crystal radio set is able to detect radio signals without a power supply. It works best if there is a transmitter within 25 miles (40 km) of the set. The antenna, a very long wire, picks up the waves and passes them through the set as electronic current, and then down to the ground. The set itself is a tuned circuit that can select a desired frequency from the many that are picked up by the antenna. The electric signals cannot be directly converted into sound because they vibrate back and forth too rapidly. The crystal (or diode) between the tuned circuit and the earphones allows the current to pass through in one direction only. The earphone contains a small solenoid and a thin metal plate. The current passing through the circuit and then through the diode causes the solenoid to move, which in turn moves the metal plate, whose vibrations create (faint) sound waves in the air.

A very simple crystal radio is not very selective, and if there are more than one nearby stations broadcasting near the same frequency, there will more than likely be some overlap, and you will hear two or more broadcasts at once. The solution is to add a tuner and a capacitor to the circuit. The coil length is what determines the frequency the circuit is tuned to. A simple tuner effectively changes the length of the coil by selecting how much of it is in the circuit. A capacitor (condenser) helps refine the tuning further.

A note about the crystal detector



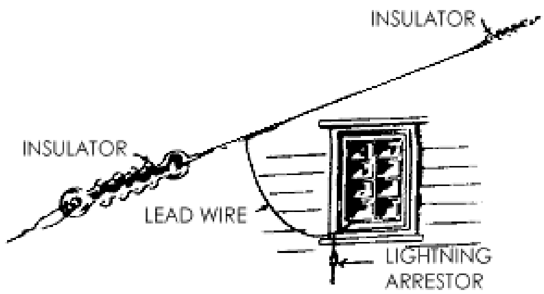
It is a fairly simple process to make a working radio using a modern diode for a detector. However, the reason these are called crystal sets is because the detector was originally a piece of crystal. You can still make your radio the authentic way with a crystal and cat's whisker. Detector stands are still manufactured, one good source being Antique Electronics Supply, 6221 S. Maple, Tempe, AZ 85283-2856 USA (phone 602-820-5411). A crystal detector includes a crystal, a cat's whisker, which is a special thin wire that contacts the crystal, and the stand that holds the components in place. The most common crystal used is a small piece of galena, which is fairly common, and can be found in many rock and hobby shops. The cat's whisker is most often composed of phosphor bronze. Once in circuit, the whisker can be moved about on the crystal's surface to find the most "sensitive" spot. The pressure of the whisker on the crystal is also adjustable. There are some other crystals that will work, so there is much room for experimentation with crystal fragments that you may already have. Also, it is not absolutely necessary to use a detector stand, and the cat's whisker can be improvised with a safety pin. Although it will be less selective and more difficult to adjust, it can be made to work quite satisfactorily. A small piece of rubber pencil eraser impaled on the safety pin helps to insulate it from your fingers while adjusting.



The coil, antenna, ground, and phones

The coils for these sets are typically wound around a 1 1/2 to 2 1/2 inch (38 - 64 mm) diameter core, using 75 to 150 turns of 24 to 20 gauge wire. These are typical numbers, not critical. What is critical is that

the individual loops of wire around the coil are wrapped touching the next one over, but that they do not ever overlap. It is also important that whatever attaches the coil to the base can not touch the coil's wire, especially if it is a metal tack or nail. A coat of shellac or varnish helps to keep the coil together. Let it dry thoroughly before using. If a wiper type switch is used, the varnish will need to be scraped away along its path.

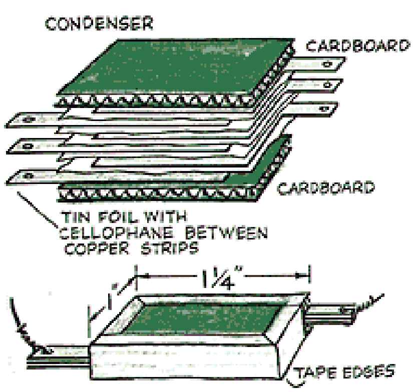


Ideally, the antenna should be 100 feet (30 m) or so long, and strung as high as possible. Insulated or non-insulated wire can be used. Either way, the un-insulated ends should not touch anything that will ground them. It is best if they are tied off to ceramic or plastic insulators, which can in turn be tied off between two high points outdoors, such as a tree limb and your house. Never string an antenna anywhere where it has even the slightest chance of coming into contact with a power line, or in a place where you will need to go near a power line to hook it up. Always take the antenna down if a storm or lightning is predicted. It is safe practice to add a lightning arrestor to you lead wire. You can purchase in many radio and electronic hobby shops antenna kits which include the antenna, insulators, lead wire, and lightning arrestor.

The ground wire can be attached to a metal cold water pipe, or to a metal rod stuck a couple of feet into the earth. Do not attach it to a line carrying gas or electricity.

The headphones (or earphone) need to be high the impedance type designed for crystal sets. They are still available through electronics suppliers and some hobby shops.

The capacitor

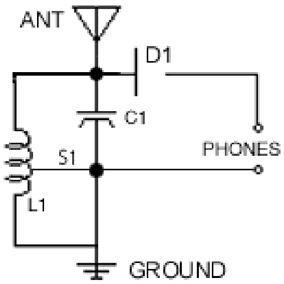


The capacitor, or condenser, though not essential for operation of these sets, does help to refine their use when it is added. More complicated sets have a variable capacitor. For the simplest sets, however, a fixed capacitor of around .002 mF or so is sufficient. A capacitor is also very simple to build. The Cub Scouts, being the great caretakers of crystal radio lore that they are, included this picture in the 1954 edition of the Wolf Cub Book. It lacked annotation of any kind other than what is here. The most important thing to know is that all of the tinfoil pieces need to be completely insulated from one another. They cannot touch each other in the least. The whole thing should be bundled tightly with cellophane tape. Also, aluminum foil is more common these days than is tin foil. It will work just as well.

Set one

What is presented here in crude ascii schematic is the simple basis of many simple crystal sets. This is not intended to tell you how to construct a particular set, but it should be enough to get a design started.

The diode D1, a germanium diode (1N34A or eq. usually recommended), is the detector, and in old sets this would have been the crystal and cat whisker assembly (see "A note about the crystal detector", above). The capacitor can either be a standard mica type of around 0.002 mfd, or a simple variable type, which you can easily build yourself based on a simple design of two metal or metal clad plates, which can be slid apart or together, and which are separated by an insulating material

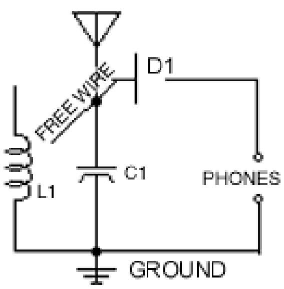


(kraft paper). L1 is the coil. Volumes could be and have been written on coils. A very simple one can be made with a 5 or 6 inch (127 - 152 mm) long, 1 inch (25 mm) diameter plastic pipe, wood dowel, or any fairly sturdy non metallic cylinder that can be easily worked with. Wind using magnet wire (#16 will work). Secure the free ends to the former somehow. The enamel should be sanded off the ends before including them in the circuit. You will have to mount the coil so that it does not contact the base. Sand the side lightly that switch S1 contacts. S1 is a simple piece of metal shaped and fastened so that it may slide across the coil. It is usual practice to attach it to the circuit with a screw or rivet loosely enough so that it can be pivoted to contact most of the coil. The ground can go to a water pipe (not a gas or electric pipe). A steel rod hammered 2 feet into the ground will also work. You can be as elaborate as you wish with the antenna. Don't use during an electrical storm! If you can't get it to work, flip the diode around. This might get things going. If not, check all your connections and make certain there is a good ground connection. You may also be using the wrong type of headphone. You will need a very high impedence phone. There are phones made specifically for crystal sets.

Set two

This design is a bit different, but mostly in the way the tuner is set up.

The coil for this set should be wound with app. 22-gauge wire, but it isn't critical. The form it is wound around is 1 to 2 inches (25-50 mm) in diameter and 4 inches (10 cm) long. It is wound in pretty much the same manner as the coils in the other projects listed here. A few inches are left loose at one end, the wire is taped down, and winding begins. Every so often, a loop of wire is left out of the winding and twisted together. This loop should be 2 inches (50 mm) or so when stretched out. Try to keep their lengths uniform. They should be closer together near the end of the coil that will connect to the ground connection. The more of these "tails" that are made, the greater the selectivity of the set. Also, as with any of these sets, the more turns in the coil, the greater the range of frequencies that can be received. When the coil is mounted to the base, one end wire is joined to the circuit. The tails are thumb tacked to the base, sticking straight out in front of the coil. The coil's other end wire is tacked to the board along with the tails.

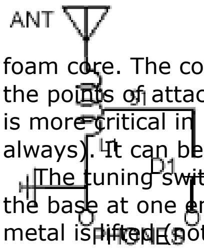


The capacitor is 300 picofarad. The enamel will need to be stripped from the coil's free ends as well as from the tails. The wire that is shown as a "free wire" in the schematic is actually the tuner. It attaches to the coil along it's tails to select frequency.

Set three: bare bones set

A crystal set can be very simple to very complex. If you want to go the complex route, which will produce a much more sensitive and tunable device, I suggest checking out the Xtal Set Society, which produces several fine books on the subject. If you want to construct a very simple one, then the schematic below is about as simple as you can get. It won't produce the easiest set to tune, but it is a great first set, and you will, if you are patient, be able to pick up several stations using it.

Using a toilet paper roll, poke two small holes about a half-inch from each end. Pass about one foot of the free end of a roll of magnet wire (#16 or so) through one of the holes, from the outside of the tube to the inside. Tape it in place. Wind the coil, making sure the adjacent windings touch but do not overlap. It should be wound firmly. When you get near the second hole, roll off another foot or so of the wire and cut it off from the roll. Pass the end through the second hole, and tape in



place. Mount the coil on the base, which is a 5 by 7-inch or so piece of wood, corrugated cardboard, or foam core. The coil should be mounted with spacers at each end, under the points of attachment, so that there is open air all around the coil (this is more critical in more sensitive sets, but it is good construction practice always). It can be attached with push pins or small brads.

The tuning switch (S1) is a piece of copper strip, which is mounted to the base at one end with a screw or rivet so that it may turn freely. The metal is lifted (not sharply bent) so that it sits on top of the coil, making good but gentle contact across the entire range. It should be positioned so that the mounted end is 2 or three inches from the coil, and centered with the coil (long ways). It is 1/4 to 1/2 inch or so wide, and long enough to cover the entire range of the coil. There should be no sharp edges, as this will wear out the coil.

You will need to add 3 terminals, two on one end of the base, and one on the other (at opposite ends of the coil). Small nails or pins work well. Sand off the enamel from the free ends of the coil's wire. Attach the wires to one of the terminals on each side. Lightly sand off the enamel under the path where the switch swipes the coil. A diode (1N34A or eq.) is attached between the attachment point of the switch and whichever of the 3 terminals is not attached to the coil. The banded side of the diode faces away from the switch.

The antenna wire attaches from the side of the coil that is opposite the diode (the side with only one terminal). It should be as long as is practically possible. Attach the ground to the terminal on the opposite side that is attached to the coil (not to the diode). The ground wire is then attached to a cold water (not gas!) pipe. High ohm headphones (the type designed for crystal sets) or an appropriate earphone is attached to the two terminals between the diode and the coil. A .001 - .002 uF capacitor can be added across the earphone terminals (not necessarily essential).

The switch needs to make good contact with the coil. If necessary, bend the end somewhat in its middle, long ways, to refine contact. Or else, solder a short piece of heavy wire to the bottom of the contact point.

Set four: Cub Scout set

This is a set which appeared in the 1943 Wolf Cub Book, part 1, pp. 75-77. The text is verbatim. It may be public domain by now, but assume for now that the Boy Scouts of America hold the copyright. There is also a nice gif image of the set from the manual. If you have trouble getting this, let me know and I will see what I can do.

How to make a simple
CRYSTAL RECEIVER

A-Dry a cardboard mailing tube in the oven, then paint with a coat of shellac. The tube should be about 6 or 7 inches long and 2 1/2 inches in diameter. Buy one pound of 26-gage (B. & S.) single cotton covered wire. Start and finish winding one half inch from ends of tube. Then shellac all over again. When dry, fasten down to a baseboard at each end, with a screw and washer to prevent it from touching at any point.

B-Cut a strip of cardboard as a test place for selector. When length has been determined, cut a brass strip the same size. Screw this down at a slight angle and mark on coil just where it touches. Fold a piece of sandpaper and with the folded edge remove the shellac and covering from wire on coil. This will leave an arc the bras strip will touch. In fastening on brass selector, use two fibre washers.

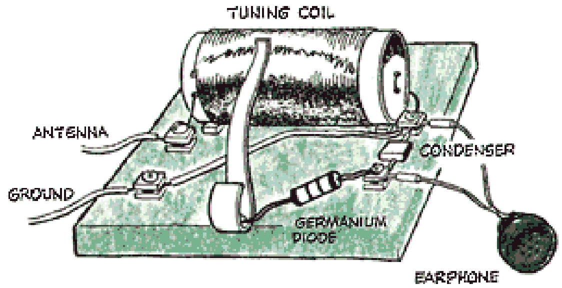
C-One end of wire from coil should go to "ground" clamp. Wire from selector should go to "antenna" clamp. Other end of coil wire should go to crystal detector. Run a wire from "ground" clamp back to one phone binding post. From other binding post, run wire to crystal. Between the phone posts, connect an .001 or .002 microfarad receiving-type fixed condenser, which costs very little.

This type of receiver works best when within 25 miles of a broadcast transmitter. Antenna and ground connections should always be tight.

- end of article

By the 1950's, the basic set changed only slightly, and has remained pretty much the same up to current Cub Scout manuals.

Final notes



This page is intended to get you started on a simple set, as well as to introduce a bit of theory to assist in constructing more complex sets. Crystal radios can be refined and precise pieces of equipment with careful design and construction. There is room for experimentation in every aspect: basic design, the coil, rheostats, the antenna, traps for the antenna (which help to filter the signal before it reaches the set), and so on. Changes in these areas can effect the sets sensitivity, range, accuracy, and even volume. Most of this is beyond the scope of this page. If you want to pursue crystal sets further, a good place to start is the Xtal Set Society. Also, you will find out a great deal on your own by experimentation.

Crystal radio lore

Gordon Johnstone writes:
"My grandfather was one of the first electric torpedo men on the Royal Navy ships during the first World War. He built one of the early crystal radios for my grandmother, but was annoyed at only one person being able to hear at any time. So he took a large pudding basin, and mounted the headset a little up from the base inside. Voila, early parabolic loudspeaker system."

Thanks, Gordon!

Construction of a diode

If you want to try your hand at making your own diode, Allan Charlton, of Sydney, Australia, adds:

"When I was a kid in a small town in Tasmania, Australia, our school was at the base of a hill, and the local radio transmitter was on top of the hill. We had lots of fun with crystal radios.

This is how we made our diodes:
Take a small length of glass or plastic tubing--an inch of the case of a plastic pen works well. Close one end with wax, sealing a wire through the wax. Pour a little copper oxide into the tube: enough to cover the end of the wire. Fill the rest of the tube with copper filings or turnings. Poke a wire into the copper filings or turnings (but don't let it go down to the oxide) and seal the end of the tube with wax.

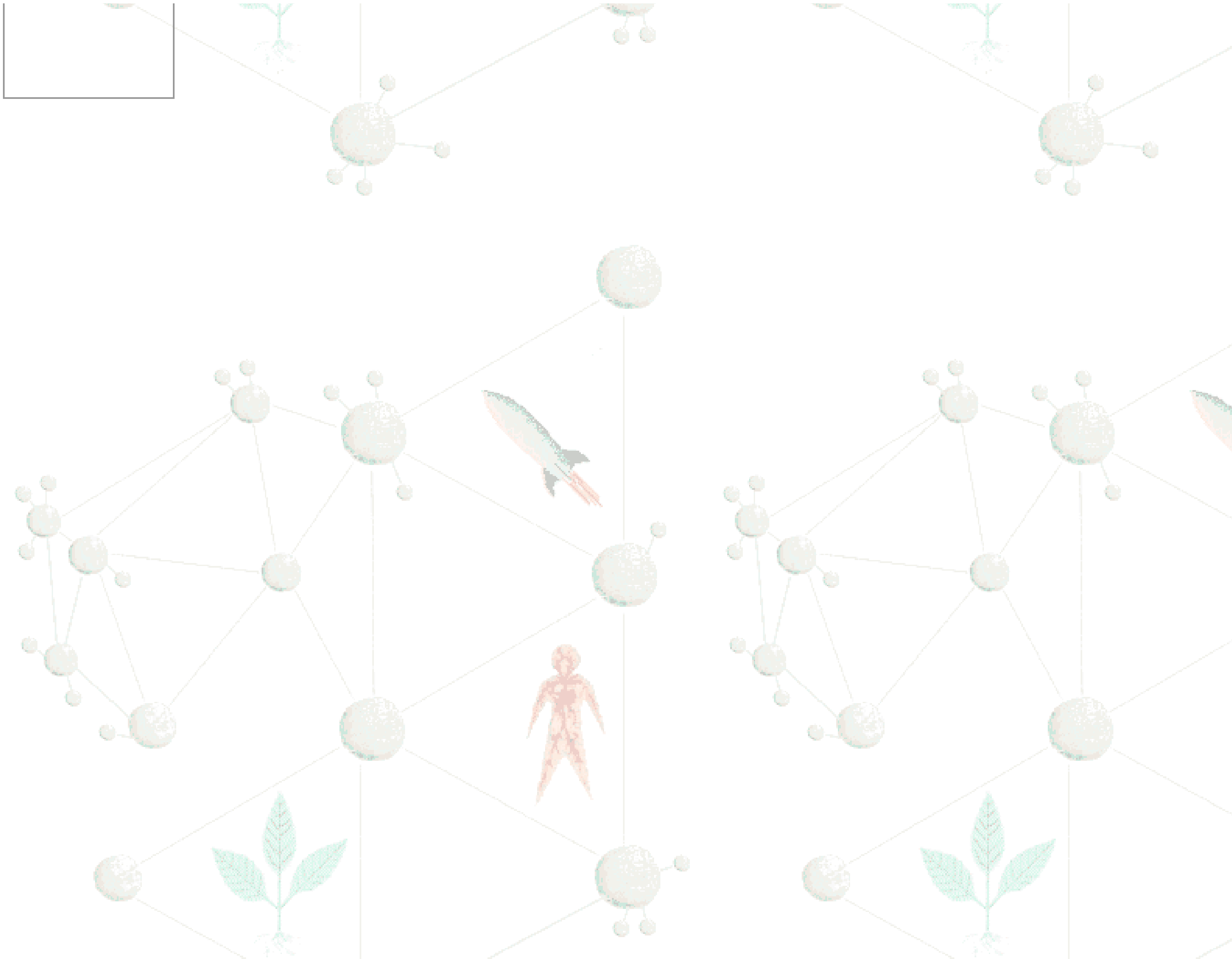
Can't find copper oxide?
Throw some copper wire into a fire. When it's cool, scrape the oxide off the wire. Yes, there are two oxides of copper, a red oxide and a black oxide, and they both work well. We preferred the red, but I have no idea why."

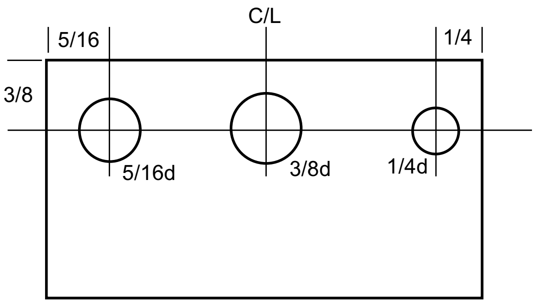
For the truly intrepid builder

In truly keeping with the spirit of this site, that is, making things from stuff you may find around the house, try your hand at the foxhole radio, which is so wonderful it get its own page.

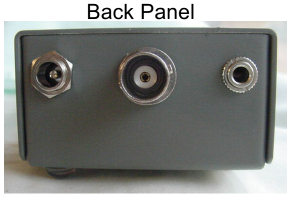
TOP | HOME | INDEX | CATEGORIES
http://bizarrelabs.com

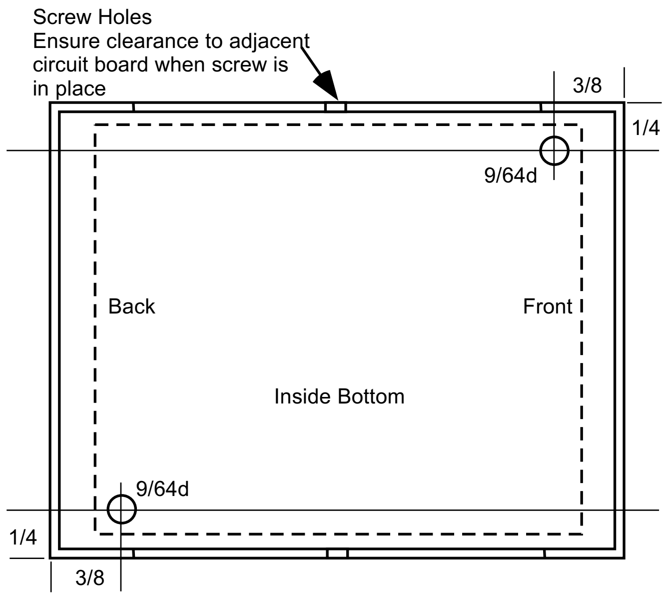
Last updated Dec 30, 2008

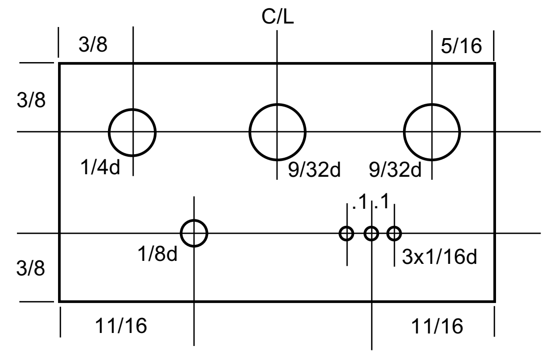




Back Panel





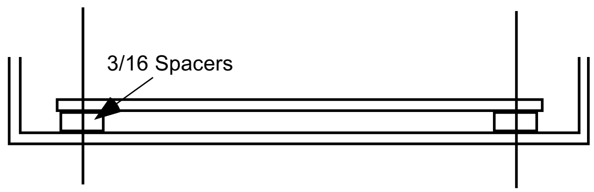


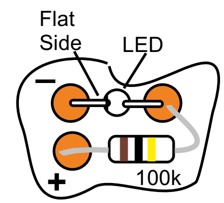
Front Panel

Parts List:
(These parts fit with the dimensions shown.)

BC#1 Enclosure -- Hendricks QRP Kits

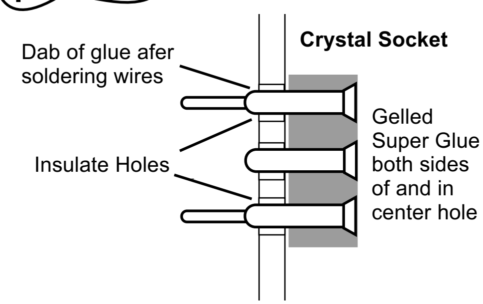
Power Jack -- 5.5 x 2.1 mm Mouser # 163-4304
BNC Jack -- Mouser # 161-9323
Stereo Jack (2) -- Mouser # 161-3402
Push Button (Grn) -- Mouser # 103-1216
Pot, 1 Meg -- Mouser # 313-1210F-1M
Knob -- Mouser # 450-CE15
LED Super Bright -- Mouser # 604-I.7104SEC/H
Bumpers (4) -- Mouser # 517-SJ-5306CL
Resistor, 100k 1/4 Watt
Crystal Socket -- 3-pin SIPP
Manhattan pads (3), 3/16 dia
Jelled Super Glue





Back of panel view --
connect power leads
to pads as shown.

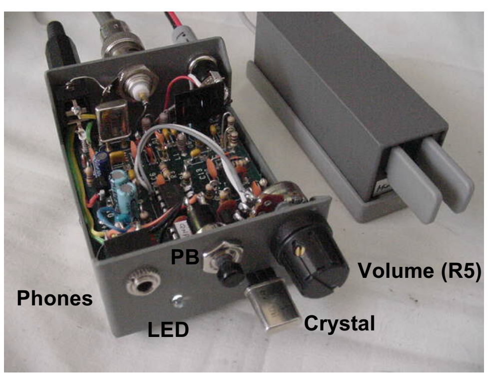
Good intensity with 100k and only
about 140uA load at 14V



Important:
Verify that there is proper clearance on both sides of the panels. Also, to the adjacent components on the circuit board. Adjustable controls often use much more space behind the panel than in front.

BC#1 Enclosure and Rock-Mite

W5USJ 28Nov'06



Crystal Socket/3-Pin SIPP
Carefully drill 3 holes 1/16 dia on 0.1 inch centers. (Actually 3 pilot holes with a #60 drill first then the 1/16 drill.) The center pin is used as part of the mechanical support but cut off up to the large diameter part of the pin. The cabinet is painted from both sides to ensure plenty of paint in the holes for insulation. The SIPP socket is mounted by putting a small dab of gelled super glue in the center hole then inserting the socket. Put another small dab of glue on the back side of the center pin. Hold the socket in place for a couple of minutes then set it aside to dry overnight. After connecting a couple of short flexible wires to the socket pins, put a small dab of glue on the back of each of the remaining two pins.

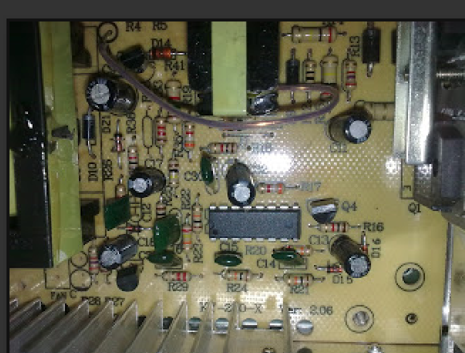
du1vss home brews

All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

Saturday, July 6, 2013

Switch Mode Power Supply Unstable Output Cure

I got this switch mode power supply from a friend and my plan was to use this on my 80W linear amp. Things went the other way when I tested this supply with my 80W amp. The output voltage won't stay at 12V and every time i keyed my transceiver, the output voltage swings to 15V and sometimes the worst hitting a peak at 17V which by any moment will surely blow the PA transistor of my amp. It took me a quite a while to figure out what was causing the issue but then it was the stray RF reaching the PWM switching regulator IC was the main culprit. My verification includes bringing a 6W portable hand held transceiver close to the switch mode power supply and pressing the PTT while monitoring the output voltage of the power supply. Every time i pressed the PTT the output voltage jumps to 17V and the proximity of the rubber ducky antenna is directly proportional to the increased in output voltage of the power supply.



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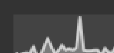

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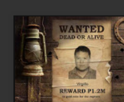

hevirred

Ham since 2000.

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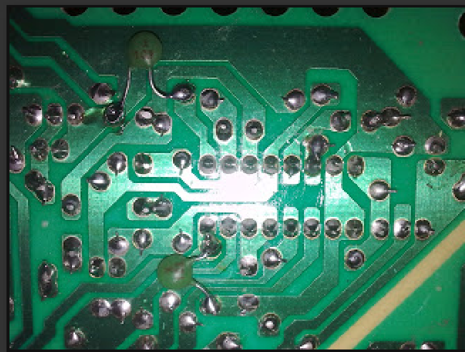

I got the courage to disassemble the switch mode power supply to access the circuit board and found the only chip mounted on the board. It was a AZ7500E pulse width modulator regulator chip that runs this power supply and found some important pins that are responsible for its regulation. I tried to bypass to ground pin1 and pin16 (both were (+) inputs of its built-in error amplifier) using a 0.01uF ceramic capacitor. After the modification I quickly reassembled the power supply and test again for stability and surprisingly works now normally. --- 73 de du1vss

Posted by hevirred at 10:36 PM

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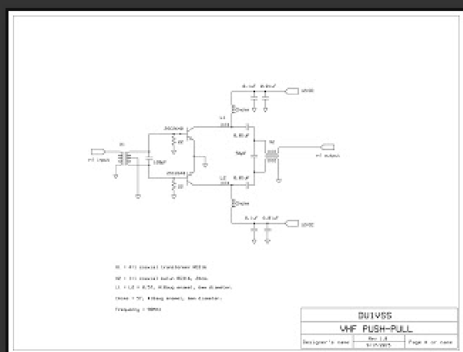
du1vss home brews

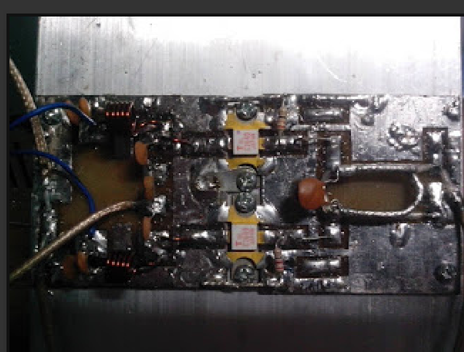
All about ham radio. Although some of my projects involved transmitters, rf amplifiers and antennas that operates outside the ham band, these things were solely for educational purpose only and experimentation.

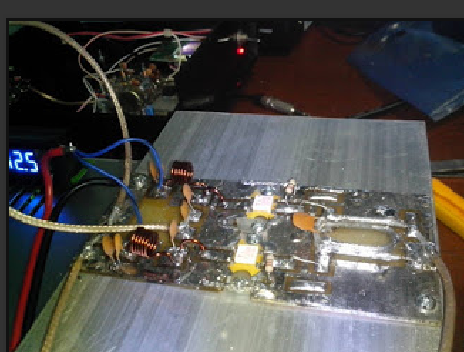
Thursday, September 17, 2015

FM Broadcast 55W Push-Pull RF Amplifier



This prototype rf amplifier uses two 2SC2640 VHF power transistor wired in push-pull configuration. The 50 ohm impedance of the input is transformed to lower impedance by the 4:1 broadband coaxial cable transformer providing a close match to the base of the two transistor. To operate in class C, the base of the transistor must be at ground potential so the secondary winding of the 4:1 coaxial transformer is grounded at the center position(null). The impedance of both collectors are transformed by the combination of inductors L1 , L2 and the 120pF capacitor and further transformed by the 1:1 coaxial balun.





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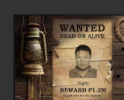

hevirred

Ham since 2000.

View my complete profile

Both the 4:1 coaxial transformer and the 1:1 balun are made from RG316 teflon coaxial cable and these are cut to a certain length in order to operate at the highest cut-off point which in this case at 110MHz. Actual test of the prototype amplifier, I was able to measure 55 watts output from a 1.5 watts input. ---73 de du1vss

Posted by hevirred at 7:06 PM

9 comments:

Gabriel Ueta April 2, 2016 at 4:01 PM

Hello,

I think there was a misunderstanding. Coaxial cable RG316 has impedance of 50 ohms. Wouldn't the cable used have to have 25 ohms?

Reply

Replies

hevirred April 2, 2016 at 11:22 PM

You are right, rg316 is a 50ohm cable. This cable was intentionally used as a 1:1 coaxial transformer hence no transformation is required. This 50 ohm cable recombines the out of phase output of each transistor into unbalance output.

Gabriel Ueta April 3, 2016 at 10:48 AM

This comment has been removed by the author.

Gabriel Ueta April 3, 2016 at 11:32 AM

Right, but the cable used in the transformer 4: 1?

hevirred April 5, 2016 at 2:14 AM

I read in some books that 4:1 transformer is made of 25 ohm coaxial cable but I have also tried several HF amplifier projects that uses binocular ferrite transformer and just wires for its broadband matching transformer and it works just fine. It provides good input and output match in my amplifier so I dont bother looking for a 25 ohm cable. You will also find that most commercial hf transceivers like icom, yaesu and kenwood also uses broadband transformers that are made just with binocular ferrite transformer and some insulated wires. I believe also that the turn ratio between secondary and primary winding determines the impedance ratio of the transformer. Thank you by the way for dropping at my blog, only a few these days are interested in ham radio. 73 de du1vss

Reply

Gabriel Ueta April 6, 2016 at 1:51 PM

You are welcome. Do the transistors have equivalent? It is difficult to find them.

Reply

hevirred April 7, 2016 at 5:48 AM

You can try the mitsubishi 2sc1946a but this is hard to find now.

Reply

Gabriel Ueta April 11, 2016 at 12:15 PM

This comment has been removed by the author.

Reply

Pedro July 21, 2016 at 10:13 AM

Hello,

I was also in doubt. If I use 25 ohm cable, is the impedance of the transformer will be reduced by half? Another thing: what are the dimensions of input transformer? It was not clear for me to build it.

Reply

Enter your comment...

Comment as: Karl Smirni (Gc ▼ Sign out

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Newer Post Home Older Post

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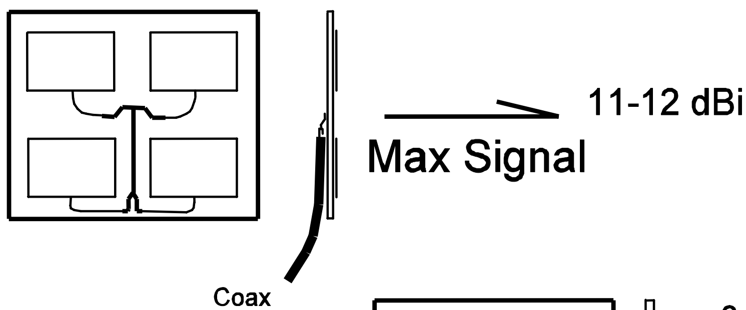
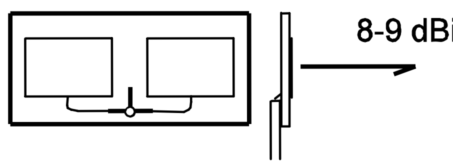
5.8 GHz Patch Arrays

WA5VJB

Vertical Polarization
As Shown



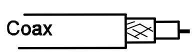


Uses: ATV Beacons Wi Fi

Repeaters Wireless Systems

Dish Feed Links MIMO

Coax Prep



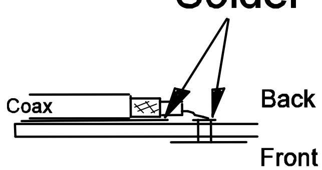
Notes:

The Coax solders to the back of the antenna.

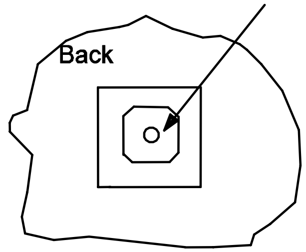
RG142 and other Teflon Coax's work well.

Use 50 Ohm Coax

Solder

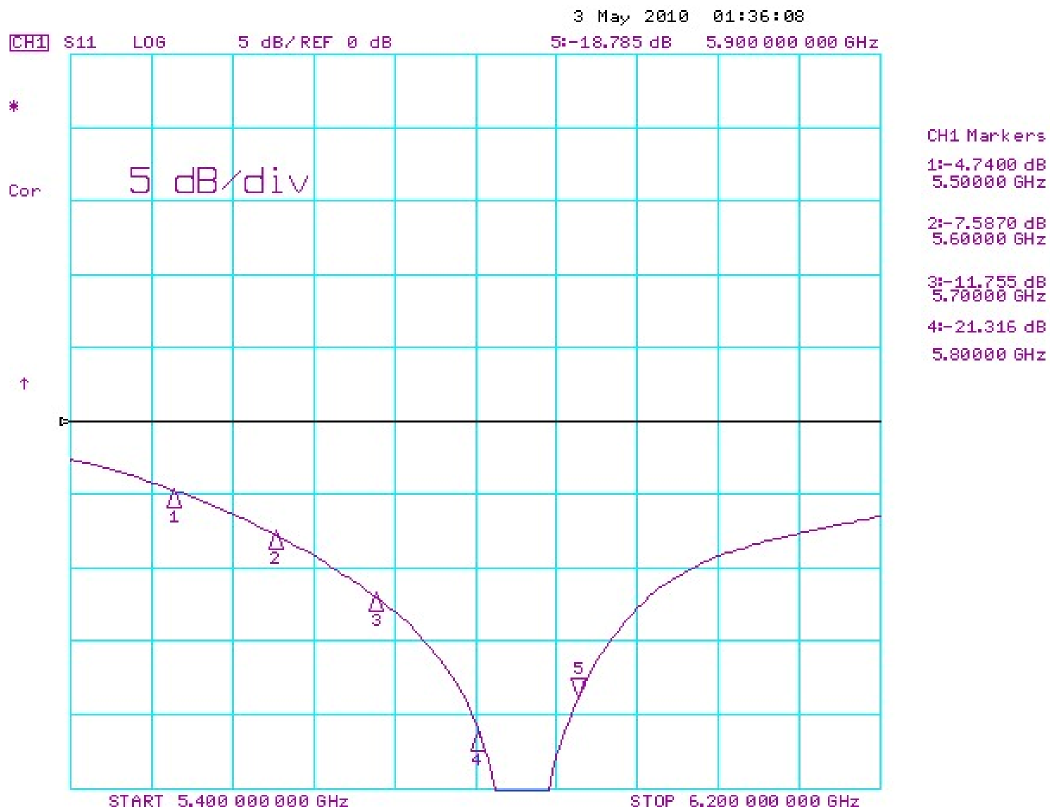


Coax Tip Here



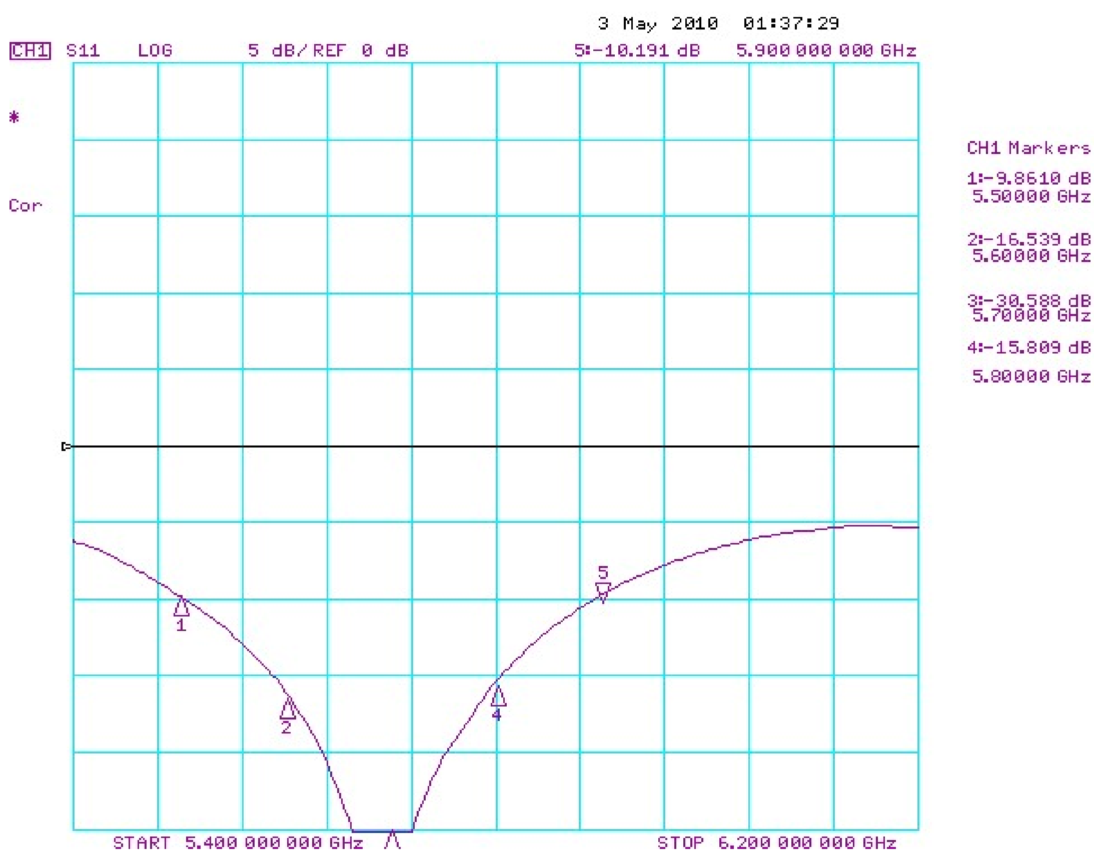
Side View

Title: 5.8 GHz Patch Arrays		
Size: B	Number: NTMS	Rev: A
Date:5-3-10	Drawn by: KEB	
File Name: 58pdata.pcb	Sheet 1 of 1	



Quad Patch Return Loss

==

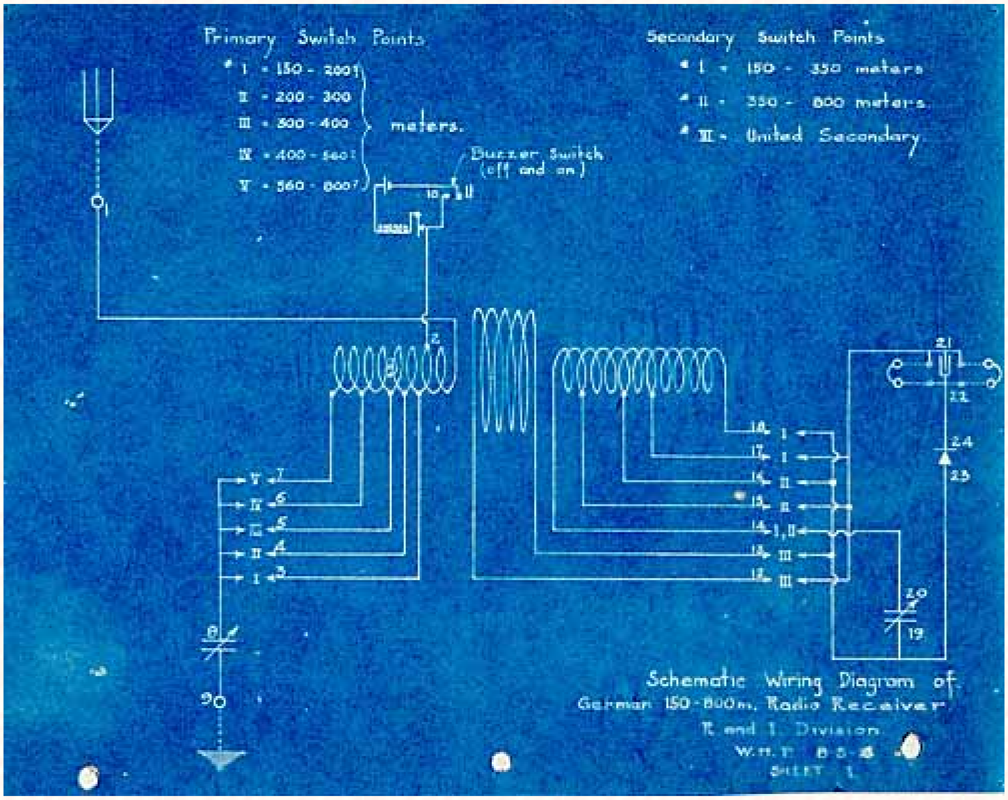


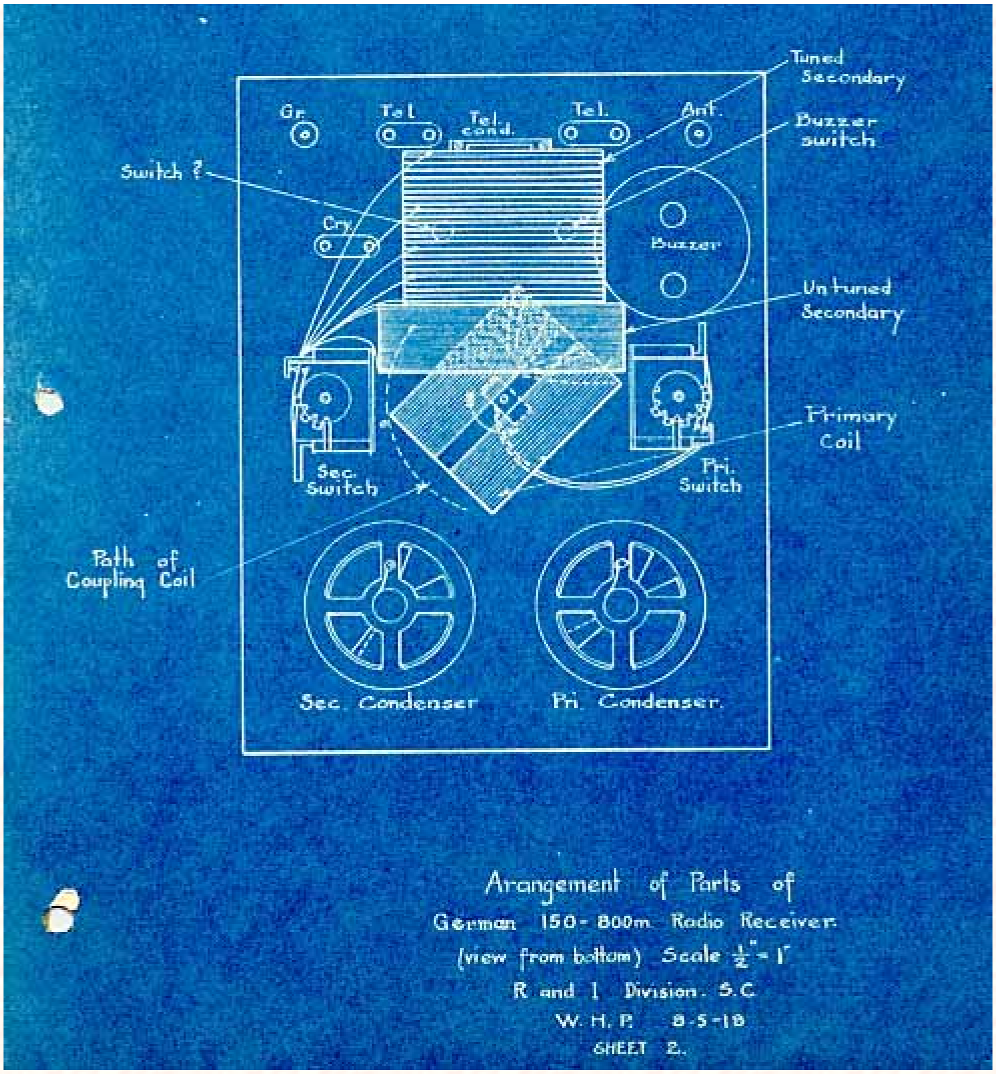
Dual Patch Return Loss

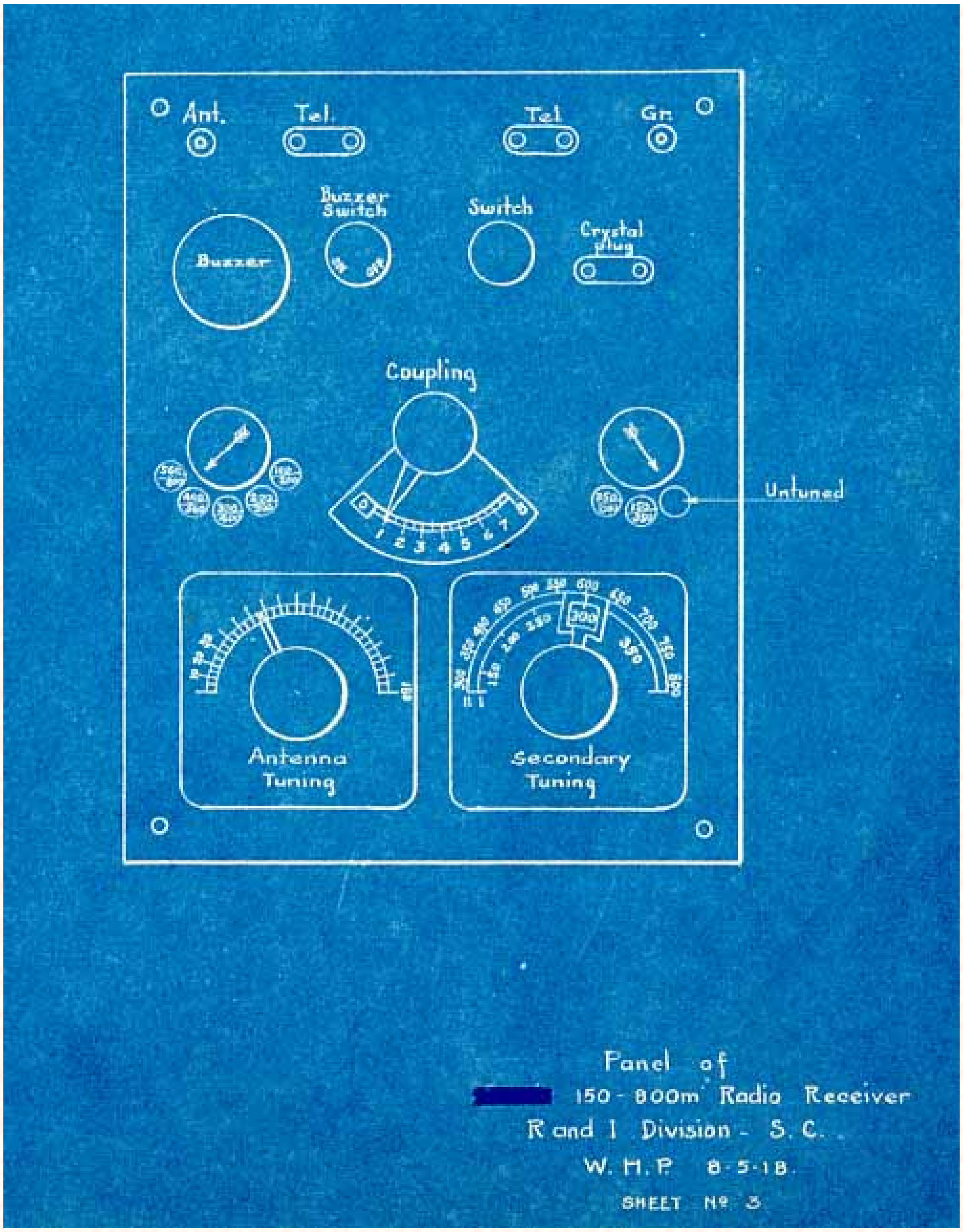
(Back) (Next) (Home)

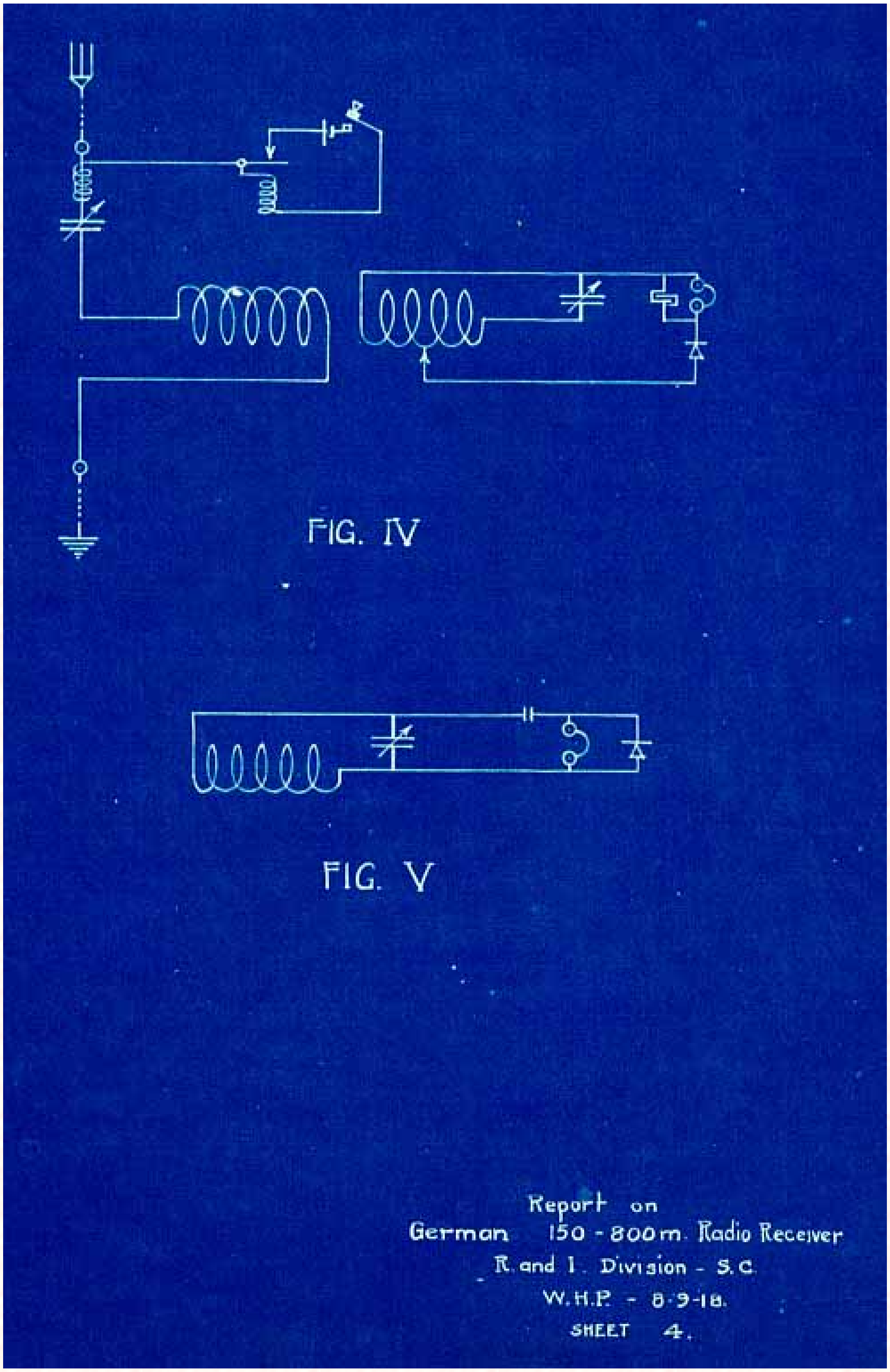
Another of the primary tasks performed by the R&I Division was the study of captured equipment.

Drawings of a German receiver.




Tuned Secondary
Buzzer switch
Gr.
Tel.
Tel. cond.
Tel.
Ant.
Switch ?
Cry.
Buzzer
Un tuned Secondary
Primary Coil
Sec. Switch
Pri. Switch
Path of Coupling Coil
Sec. Condenser
Pri. Condenser.
Arangement of Parts of
German 150-800m. Radio Receiver.
(view from bottom) Scale ½" = 1"
R and I Division. S.C.
W. H. P. 8-5-18
SHEET 2.


Ant.
Tel.
Tel
Gr.
Buzzer
Buzzer Switch
Switch
Crystal plug
Coupling
Untuned
Antenna Tuning
Secondary Tuning
Panel of
[redacted] 150 - 800m Radio Receiver
R and I Division - S. C.
W. H. P. 8-5-18.
SHEET Nº 3



[(More)](http://users.erols.com/oldradio/eha13.htm)

N5ESE's Version of the

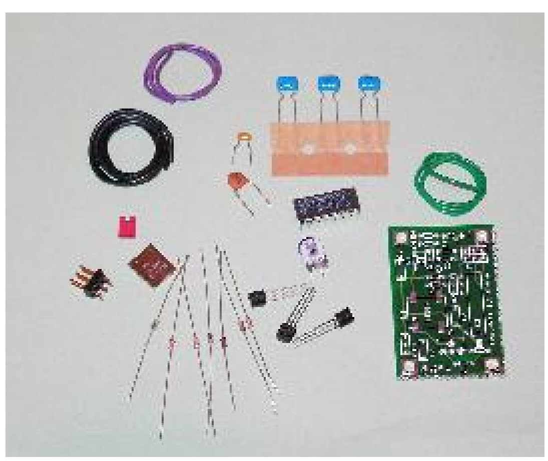
W8DIZ Frequency Reference

(click on any picture to see larger version)

Dieter Gentzow, W8DIZ, of www.kitsandparts.com provides an inexpensive ($17) kit that generates a trimmable, crystal-based signal of reasonably good stability for use as a hobbyist "frequency standard". Output is at 10, 5, or 2.5 Mhz with sufficient output level to drive most frequency counters. Diz says he intended this to use for adjusting CW-annunciated frequency counters, like the A HREF="http://www.smallwonderlabs.com/">SWL Freq-Mite kit.

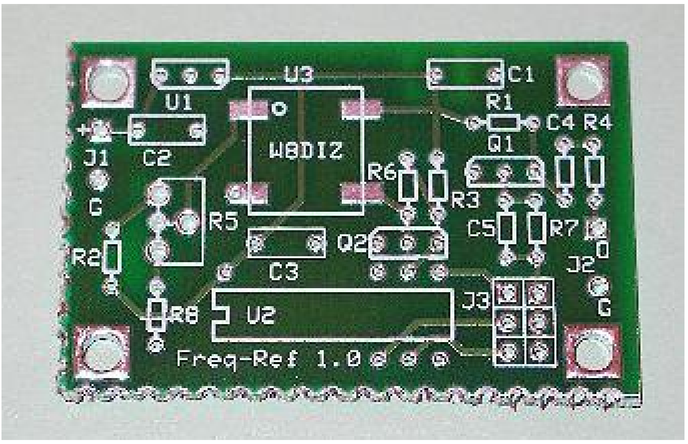
What does it consist of? Well, a three-terminal regulator drops the source voltage to 5.0 Volts for the oscillator and other circuitry. The oscillator IC outputs a small sine wave at 20 MHz, which is amplified and digitized (using an NPN transistor) to drive the clock input on a binary counter chip. The first 3 stages are used, providing divide-by-2, 4, and 8 (10, 5, and 2.5 MHz). A jumper selects one of those three clock signals, which drives an NPN transistor to the output. A unique thing about the oscillator is that it is voltage-trimmable; that is, applying a DC voltage at the adjust pin (via a pot-trimmed voltage divider) allows one to adjust the oscillator to the exact frequency. You can't do that with your run-of-the-mill oscillator circuit.

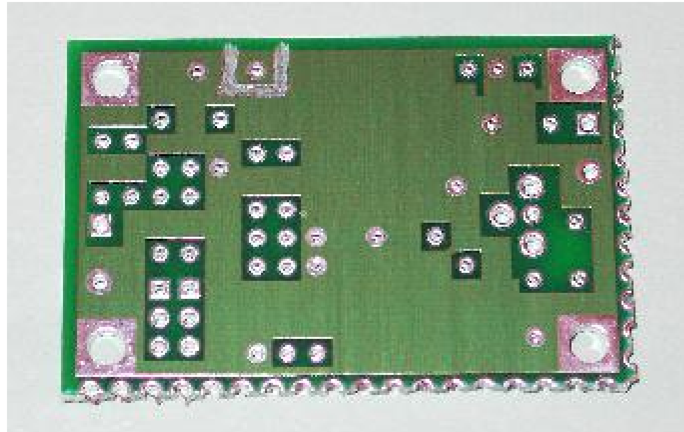
Here's a picture of what you get for your hard-earned 17 smackers:



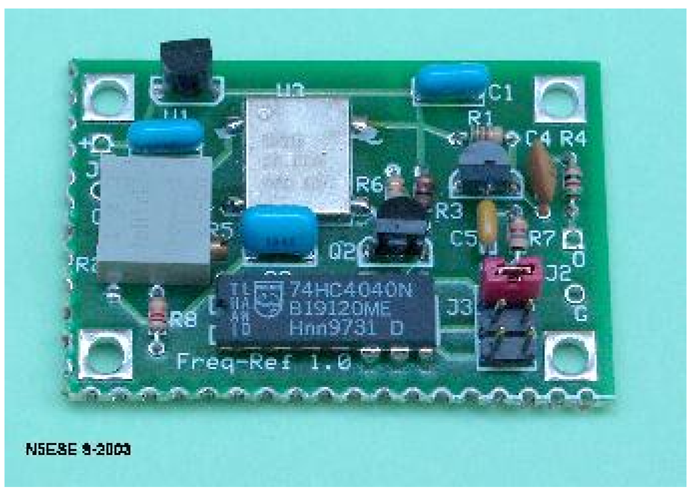
As you can see, there are not a lot of parts, but a few are worthy of comment. The key component is the TCXO oscillator. That's the metallic box just to the left of the resistors. It's a 4-pin surface mount device. Not to worry, you smd-phobes, that's the only surface mount part, and it's a snap to install. Also notice the PC board. This is a

double-sided board with plated through holes. It's not the prettiest board I've ever seen (it has a mistake corrected on the bottom, which you can see corrected in the image below, and rough edges on two sides), but it's perfectly functional. If you pride yourself in making ugly things work (or making things that work, ugly), you'll have no problem with these boards. Here are some pix of the bare boards, top and bottom:





Parts assembly is semi-straightforward, but be forewarned - you don't get printed instructions with this. Wait, don't panic! - you can download them from the internet site, and print them at home (3 pages, including schematic). There is one really odd thing about mounting the 74HC4040 DIP IC - there are no holes drilled in the PCB for the unused outputs, so before you mount the IC, you need to cut or break off those pins. The risk here is that you'll count wrong and cut off the wrong pins, then end up having to wait for another chip. Diz has a semi-sound reason for doing this - he wanted to avoid radiating from the unused output pins. Hmmm. Here's the completed assembly, before mounting in an enclosure:



Those with sharp eyes will note a modification on my version. To make setting to frequency a little easier, I mounted a 10-turn pot in place of the single-turn pot provided. This meant that I had to move one of the resistors to the bottom. I wouldn't call this a required mod, at all. If I hadn't already had the pot in my junk box, I would have been quite happy with the one provided by Diz. I also had a bad 2N3904, which had to be replaced in the output circuit, again from my junk box.

I decided to mount mine in a - what else? - Altoids tin. There's more than enough room for the board, a switch, a BNC connector, and a 9 Volt battery. You can see the finished product in the image at the top of the page. The switch is mounted in an unusual way. I took a piece of 5/8 x 5/8 inch double-sided scrap PCB, drilled a 1/4-inch hole in the middle of it, and soldered it directly to the inside of the Altoids tin. Then I mounted the switch. This way, the switch is not sticking out of the Altoids, waiting to be broken off or switched on accidentally. Really, the switch is not even necessary - you could just as easily connect or disconnect the battery, to turn the unit on and off.

How does it work?

Actually, it works quite nicely. It drifted about 4 or 5 Hertz in the first minute or so. Diz recommends a 10-minute warmup before setting it, but I didn't note any drift after the first minute. Thereafter, the unit holds its frequency pretty well. I was able to set it to within 0.1 Hz of 10.000 MHz using a ten-second gate on a calibrated lab-grade frequency counter, and it stayed within 1 Hertz for the next two hours. Letting it cool, and turning it on again, it settled to within 1 Hz of its former frequency within a minute. I hit it momentarily with a heat gun, to simulate a small temperature change, and it maintained its frequency within 4-5 Hz. Pretty good stability for a $17 reference oscillator.

Diz suggests zero-beating the oscillator with WWV on 10 or 20 MHz. I tried it, and it ain't as easy as it sounds. When I did it, I thought I had it zero beat, and it turned out to be about 11 hertz off frequency. I think I may have been beating against one of the sidebands of WWV, or else against a shortwave broadcast carrier that was almost on top of it. Or else, I was overloading my receiver. Anyway, I finally ended up taking it to work and adjusting it against a calibrated instrument. Subsequently, I've been able to tweak my bench counter (at home) and several CW annunciators to much closer tolerances, using the Frequency Reference as a known source.

Current draw meausred 26.5 mA from a 9 Volt battery, which means you'll be changing that battery fairly often if you forget to turn the unit off.

Bottom line? If you have need of a cheap-and-dirty frequency reference, this kit is the one for you.

73,
monty N5ESE

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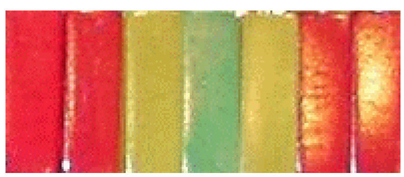
N5ESE Builds the Jackson Harbor Son of Zero-Beat

(click on any picture to see larger version)

Here is another "zerobeat" tuning aid, with a few more visual cues than my own zerobeat project. In this kit, costing about $25, and supplied by Jackson Harbor Press, a really unique approach to visual tuning is provided. Besides, it has lotsa lights, and who doesn't like lotsa blinking lights?

The "Son of Zerobeat" (as it is called), utilizes an audio bandpass filter and a PIC microcontroller as the central elements of the circuit. Audio from the headphones or speaker circuit of the receiver is filtered, then sampled by the PIC. The PIC acts like a crude signal processing engine, to provide frequency discrimination in 7 bands. For a single unknown tone in the audio, as when receiving a CW signal, the PIC will light one of the seven LEDs. If the received signal's frequency is within 10 Hz of the center frequency (selectable by the operator), the green center LED will illuminate. Otherwise, one of the other yellow or red LEDs will illuminate, indicating the direction (lower or higher pitch) and distance from the center frequency.

OK, let's say it all another way. Imagine 7 LEDs lined up, left to right, in front of you.



The center LED, which is green, will light when the received signal is within 10 Hz of the "center frequency". The yellow LEDs would light if we were off center by 30 Hz, with the left lighting if the pitch is lower, and the right lighting if the pitch is higher. For frequencies even lower and higher, the respective red LEDs would illuminate.

If we were to start with a very low pitch signal and slowly raise the pitch, we would see the leftmost red LED light up when we are about 110 Hz below the center frequency. As we continue to raise the pitch, the next LED would light, and the first would go out. Continuing, we would see each LED light (and go out) in succession until the green center LED lights, indicating we are within 10 Hz of our center frequency. As we continued raising the pitch, we would see the green go out and the yellow to the right of it light up, and so on until we reached the rightmost red LED, indicating we are more than 110 Hz above the center frequency.

In this way, then, we could use the Son of Zerobeat to help us visually tune our receiver to the correct pitch indicating "zerobeat" with the received signal. Now, when we transmit, we can be reasonably confident that we are close to the received signal's frequency, and within the remote operator's passband.

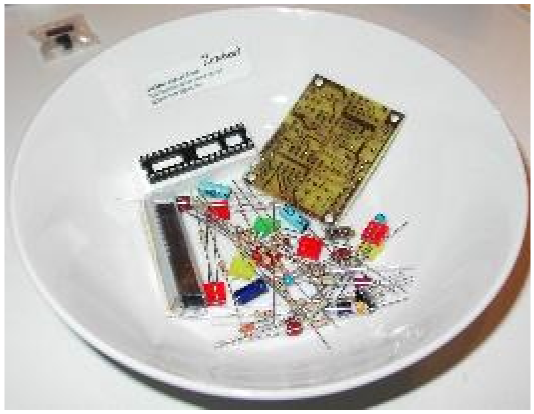
By the way, the center frequency can be set to any pitch in the range 400-1200 Hz. You do this by applying a clean strong signal (with the audio pitch you want "center" to be), then pushing a momentary pushbuitton (or

shorting two points) briefly, whereupon the PIC microcontroller "memorizes" the new center frequency. I set most of my rigs for 600 Hz, so that's where I set the Son of Zerobeat.

The 8th LED is operated from a threshold detector, and can be seen to light in sync with the CW signal (provided that the signal is moderate to strong). It is affected only by amplitude, as set by a trimpot onboard the pc board, and is pretty much frequency insensitive.

Construction

Here's a picture of the kit before assembly:



(click on the above picture to see larger version)

Assembly is straightforward, and soldering up the PC Board takes between 1-2 hours, depending on your experience level. I decided to package mine in my favorite enclosure - what else - an Altoids tin. I wired the input so that I could route the received audio in on a stereo jack, and route it out on a stereo jack. Essdentially, I made a headphone "Y" cable, except I put it inside the Altoids tin, tapping the audio to go to the Son of Zerobeat board.

The PC Board is so small, there's plenty of room for a switch and a 9-Volt battery inside the Altoids tin. I mounted the slide switch (power switch) on small spacers I grabbed from the junk box. A small 3-conductor patch cable was homebrewed, to connect the Son of Zerobeat to the receiver, and fits easily inside the Altoids tin for transport. Headphones, then, connect to the second jack on the Altoids tin, providing receiver audio to the operator.

How's She Sail?

Hooking it up on the bench, we provided a signal generator to the input of the receiver, and connected the Son of Zerobeat to the headphone jack. Sweeping the signal generator pretty much confirmed that the Son of Zerobeat worked as advertised, and it was super-easy to adjust the received signal for the center tone.

The real test came when we took it to the field, and hooked the receiver up to a real antenna. The Son of Zerobeat does quite well on strong (S7+) signals that have no QRM within a few hundred hertz, but noise and QRM tend to make the lights flicker randomly, and one ends up tuning by ear for weak to moderate signals or signals on a noisy or crowded band.

Still, it's hard to beat those flickering LEDs - ooch! Did I say "beat"?

73,
monty N5ESE

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N5ESE Builds the
M-Cubed FPM-1 Frequency/Power Meter

(click on any picture to see larger version)

I was recently quite fortunate in being invited by the designers at M-Cubed Electronics to participate in the beta-build of their FPM-1 Frequency/Power Meter Kit. It is due to be announced the weekend that I write this (Nov 18, 2005), and I want to get a review online immediately, to let prospective buyers know what I thought of it. So, to make a long story short:

WOW !

This is a pretty cool little portable instrument. It has more functionality than most instruments in this cost range, the feature set is amazing, and the ergonomics are first-rate. It measurement accuracy rivals laboratory equipment, at far, far fewer dollars. And anyone with a modicum of soldering experience will find it easy to assemble. (Note, it may not be for the beginner).

So, What Is It, Already?

It's really two instruments in one compact package: a sensitive, wide-range **frequency counter**, and a versatile, wideband **RF power meter**.

First, it's a first rate frequency counter, capable of measuring frequency up to 1.3 GHz *(!!!)* to within 2 ppm or better, and with 7 significant digits of display resolution. Two inputs are provided for frequency measurement. Input Port 1, the high-impedance input, measures from 2 Hz to 80 MHz. Because the counting method employed uses the "reciprocal" technique, readings taken at low frequencies enjoy the same 7-digit resolution as higher frequencies. That is, not only can you measure a 20 MHz signal with 10 Hz resoluttion, you can enjoy the same 7-digit resolution at, for example, 2.467224 Hz. Input Port 2, with a built-in prescaler to cover frequencies up to 1.3 GHz, is a low-impedance (50-ohm) port.

Secondly, it's a wideband RF Power Meter. And not just any run-of-the-mill power meter. This meter can accurately measure over a frequency range from 1 to 500 Mhz, and is usable up to 800 Mhz! This meter has a typical measurement dynamic range of 88 dB or more, measuring from -72 dBm to +16 dBm to within 1 dB, with a display resolution to 0.1 dB. Let's put that in perspective. -72 dBm is 63 **picowatts** (!!!) which is an 'S9' signal into a ham receiver. +16 dBm is 40 mW. Now, you may be thinking to yourself, what use is that? But if you do any homebrewing of RF circuits, I'm betting there were many, many times in the past when you wished for more range (freq and power) than your RF Probe. And you probably wondered if you could even *trust* a low reading on your RF Probe. Wonder no more.

With the addition of a simple external attenuator, which can be built for less than $10, you can extend the range of this meter to nearly 400 Watts. That's a compounded measurement dynamic range of over 130 dB. Amazing! Think of it, with the attenuator, you could measure from less than a **microwatt** to 200 Watts, with typical 0.5 dB accuracy, over the entire HF and VHF range. That's really a *lot* of measurement capability.

Measurement capability aside, it's really the feature set built-in by the skilled programmer(s) at M-Cubed that makes this instrument such a pleasure to use. Let's give an example or two which are especially useful for those who like to build and test RF circuits and radios, like myself.

Cool Feature No. 1 - Ergonomics

The first thing you notice when looking at the FPM-1 is the neatly arranged front panel, with the large (2 lines x 16 character) LCD, and 4 small pushbuttons. Above the buttons, in white silkscreen, lables which apply upon default power-up functions. These are "base-level" functions. Below the buttons, in yellow silkscrren, are the base-level functions for the power-measuring mode. But there are many internal menus for selecting functions, making adjustments, and setting memories. These internal menus show up as software lables on the bottom line of the display, right above the hardware buttons.

For example, if we push the rightmost button (CH1/CH2), we get the following display:

On the bottom of the display, the three lables [CH1] [CH2] [PWR] refer to the current function of the three leftmost pushbuttons, indicating that the current button functions select Frequency counter Channel 1 (0-100 MHz), Frequency Counter Channel 2 (50-1300 Mhz), or the Power Meter. This is the manner in which you select which function (and BNC input jack) is active.

Of course, there are many more functions, which can be found in the documentation... and that leads me to:

Cool Feature No. 2 - Documentation

The staff at M-Cubed has done a superb job of documenting the FPM-1. It begins with the Assembly Manual (this **is** a kit). Being a Beta-Tester, I expected to see lots and lots of errors. There were surprisingly few to begin with, and they were readily corrected, resulting in assembly instructions that are illustrated with pictures wherever any uncertainty exists. And, of course, clear schematics, parts lists, and board outlines round out the package.

The operating (user) manual is nothing short of superb. Each function is accurately and clearly documented, and each menu panel is illustrated. I read through it once, practicing each mode as I went along. After that, the menu functions seemed intuitive and natural, meaning I no longer needed the manual.

Cool Feature No 3 - Frequency Measurement Flexibility

On either Channel 1 or Channel 2, you can select to measure either frequency or period. To support frequency measurements, you can also select gate time as 0.1, 1, or 2 seconds (which affects resolution and display update rates inversely). Here's a picture of the FPM-1 measuring the frequency of my dual-band HT's transmitter on the 70 CM band, through a short antenna connected to CH 2:

(click on the above picture to see larger version)

On Channel 1 only (0-100 MHz), you can also Totalize (i.e., count pulses), and measure Pulse Width and Duty Cycle.

A really cool feature of frequency measurement, as a result of having a microcontroller onboard, is that some internal calculations can allow some very useful features to be implemented, based on the frequency count. One I found particularly intriguing is the ability to set a measured frequency as a reference (i.e., display it as zero). What then results on the display is a measure of the difference. This is perfect for measuring drift in a VFO or crystal oscillator, for example. Turn on the oscillator cold, get the initial measurement, go to the HOLD submenu, Press MOD, then F-O (meaning 'Frequency - Fo'). The unit begins to measure the frequency as usual, but now displays the deviation from the original "held" frequency. Now it's an easy task to observe the drift over time.

As an aside, one need not worry about the internal reference oscillator drifting. It's a TCXO, and after about 10-15 minutes warm-up, should be +/- 1ppm of it's nominal frequency. That's a good, stable oscillator.

The FPM-1 can also be used as a display, with offsets and difference modes to accommodate the conversion scheme of any superhet receiver. Just drill down into the HOLD | MOD submenus (the manual explains this quite succinctly).

The frequency counter's sensitivity is very usable across the entire range, and the triggering is remarkably insensitive to noise. I found that I could hang a 12-inch BNC antenna on either input, and easily measure the frequency of the radiated signal of my QRP HF rig, and my Dual-Band HT.

Cool Feature No. 4 - Power Measurement Flexibility

As we mentioned earlier, the power metering is state-of-the-art: excellent sensitivity, good accuracy and resolution, wide measurement dynamic range, and wideband capability. For straight-ahead power measurements from -72 dBm to +15 dBm, it simply can't be beat - that is, without spending a kilobuck or two.. But where it really shines is what you can do with that to make it even more useful.

Once again, it's the presence of a microcontroller (with some really top-notch firmware) that's makes these extra features possible. Take frequency compensation, for example. The RF power metering mode covers the range from 1 MHz to 500 Mhz, and is rated to within +/-1 dB across that range. One of the reasons that's possible is because a correction is applied to the raw measurement (before it's displayed), based on the frequency the power meter believes is applied. Now, the power meter doesn't really know what the frequency is, unless you tell it, and there are a few ways to do that. One way is to measure a frequency (in counter mode, at input 1 or 2), and then press HOLD. Now, when you switch to RF Power mode, that frequency is retained on the display, and in memory, for use in determining the correction to RF power. Cool!

Another way to tell the RF Power Meter what frequency it's at, is to select a value stored in one of ten memories set aside for that purpose. You can set those memories individually, either by measuring an actual frequency, or keying it in with a very clever method using the front panel buttons and prompts on the display. I set my ten memories to the center of the each major ham band from 3.5 MHz to 440 MHz, because those are the frequencies, as a ham, that I'm most likely to measure. Now, when I want to measure the power on my QRP rig, I just "recall" the band's center frequency, and go to power mode. Awesome! Takes just a few seconds.

Another supercool power meter feature is the ability to correct the displayed value for external attenuators and amplifiers. Let's say that you're probing a front-end receiver circuit using an amplifier with +13.7 dB of gain. Using the ATT submenu, you can set the "attenuator" offset to any value from -40 to +40 dB. In fact, much like the preset frequencies, you can store up to ten attenuator values in memory, for recall at will. In our example, the power meter would now account for the +13.7 dB of external amplification, and display the power at the **input** to the external amplifier (rather than the input to the power meter). Very Cool!

The way I find this feature most useful is in measuring the output power of my ham transmitters. To do this, I use the 40 dB tap attenuator I mentioned earlier, tee'd off from an external dummy load. Then, I set the ATT feature for 40.1 dB (the actual attenuation of my tap attenuator). When I subsequently transmit, I measure the actual transmitter power +37.0 dBm, in spite of the fact that the FPM-1 is only capable of measuring to +15 dBm. Radical!

But wait, there's more. I can't stand reading my transmitter power in dBm, so do I have to carry a calculator? Nope! I press the dBm/mW button on the front panel, and the FPM-1 does that for me: 5.01 watts. Yeah, baby! Here's a picture of it doing exactly that:

(click on the above picture to see larger version)

Kit Construction

This is a pretty simple kit to assemble, but I wouldn't recommend it for beginners. Otherwise, the average kit-builder, with a modicum of patience, should have no problem. There are two high-quality (silkscreened and masked, with plated-thru holes) printed circuit boards, and the pre-fab display assembly to contend with. For those who are SM-phobes, surface-mount IC's come pre-mounted,. It's pretty straight-forward assembly. There's a lot of electronics in that box, and it goes together pretty nicely. There are very few potential amiguities in the assembly instructions, and those few tricky parts are now illustrated with clear diagrams and photographs.

Probably the trickiest part of the assembly - and also most critical to performance - is the installation and soldering of the RF Power input coax (three-inch piece of RG-174) and the brass shields which cover that cable and the AD8307 power detector chip circuitry. The brass shield must be cut and bent carefully, as explained in the manual. It requires a bit of mechanical finesse, something I'm not exactly renowned for. I had to do my shield and coax twice before I got it right, and managed to break the fragile input resistor in the process. All's well that ends well, and as a result of my fumbling, a few more explicitly detailed instructions and pictures appear in the assembly manual ;-)

There is some point-to-point wiring from the main board to the various connectors in the enclosure, and to the power switch. It is best to fully test your unit functionally before you solder-in those BNC connectors or solder-mount the shields, because once they are mounted, you can't get to the bottom of the main pc board to do troubleshooting or remove components. That point is perhaps NOT clear in the manual, and I learned the hard way how to swap out a DIP chip in close quarters from the TOP of the board. It warn't easy!

At the bottom of the page, I've included links to various pictures of the internal workings of the FPM-1. Be aware that this was a beta build, and although it's substantially the same, you shouldn't be following my construction too closely.

Calibration Procedures

The FPM-1 requires calibration to set the "slope" and "intercept point" of the logarithmic power detector, and also to tweak the internal reference (20 MHz) TCXO oscillator to exact frequency. I suppose it's the "catch-22" of test equipment that, in order for it to measure accurately, you need good test equipment to calibrate it. In order for the frequency counter to measure accurately, you need to set the reference oscillator accurately. And in order to set the power detector accurately, you need two accurate reference points. Sigh.

If you have lab grade equipment suitable for use as a secondary standard (i.e., for calibrating other equipment), I'm not sure you would need this piece of equipment in the first place, unless for it's relative small size. Sure, you can use cruder equipment or approximations for calibrating, but the accuracy will suffer. So, just what do you need? Well, M-Cubed wants you to tweak the reference oscillator using a 10 MHz input that's stable to within +/-2 ppm. That means either a very accurate signal generator (most aren't that accurate), or a signal source that can be tweaked to WWV exactly. Actually, the latter method is quite do-able, and will probably serve to get the reference oscillator adjusted to within a Hertz. M-Cubed offers yet another method, which I'll explain in a minute.

M-Cubed wants you to adjust the slope/intercept of the power detector based on two 10 MHz input signals which are known to be accurate within 0.1 dB (about 2%). The calibration procedure suggested by M-Cubed involves adjusting the slope so that a signal of 0 dBm and one of -30 dBm read 30 dB different (exactly), and then they store an offset in memory (as a fixed calibration factor) at 0 dBm. All well and good, if you have two accurate power sources. How many of us can be sure?

One solution would be to use a 40 dB tap attenuator of known value (like that described -here-) or, alternatively, fixed or stepped inline attenuators (also of known accuracy), and apply a higher power signal, like 5-10 watts, at the input of the tap attenuator. You could measure the higher power using an RF Probe (look -here- or -here- for examples) or an accurately calibrated Oscilloscope (I usually don't trust scope calibrations at RF frequencies). For example, with the 40 dB attenuator, a 30 Meter transmitter output adjusted to 22.4 Volts RMS at the dummy load would provide 0 dBm at the power meter input, for calibration. Thereafter, you just need a fixed 30 dB inline attenuator to get the second calibration point of -30 dBm. If you can tolerate a little reduced accuracy, you can do the second calibration point at -20 dBm, instead of -30 dBm. You can pretty easily build an accurate inline attenuator using 1% resistors, or build a step attenuator like the one shown -here-. It should be mentioned that the clever engineers at M-Cubed recognized that some folks would like to pick their own power calibration points, and a provision is included for setting the calibration offset at some power other than 0 dBm. Man! Those guys thought of everything!

They really did think this through... and to support calibration for those who don't have access to lab equipment, they offer an inexpensive Calibrator for the purpose. The M-Cubed Calibrator comes fully assembled and ***pre-calibrated***, with its own TCXO tweaked to within +/- 1 Hz, and switchable power levels of 0, -10, -20, and -30 dBm, all accurate to within 0.1 dBm. Here's a picture:

(click on the above picture to see larger version)

I took my beta Calibrator to work to put on a laboratory grade power meter, and found the 0 dBm output to be 0.08 dB off, and the other switch positions to be within 0.2 dB of their nominal settings. That's after traveling across the country via UPS to get here. Not bad!

Measured Performance

Except for some spot measurements on the ham bands from 160 Meters through 70 CM, I didn't do any stringent testing on the frequency meters. I found them, however to be quite robust across the range, and sensitive enough for virtually everything I tested them on. I saw very little evidence of false triggering; when I did, it was usually the result of a ground loop in the equipment lashup, which was apparent when it occured, and easily remedied. The same thing happens with my other (commercial) frequency counters.

I went to some trouble to evaluate the power meter, and as a result, I was quite impressed. For these tests, I used my Logimetrics 925 Signal Generator, which I believe has an attenuator that is accurate to within 0.5 dB across the measurement range of interest. It's specs are wider (+/- 1.0 dB for the attenuator, +/-0.5 dB for the leveling), but it seems to be much more accurate. Based on this, anyway, I conducted my tests, so you should keep in mind when observing the results that it is impossible to delineate any deviations as being from the power meter, or from the signal generator. That said, I still think the results are useful observations.

I looked at the overall measurement dynamic range, in an attempt to see what the basic measurement accuracy would be in real life. The M-Cubed spec is:

- "-72 to +16 dBm maximum (sic), typical -70 dBm to +15 dBm depending on frequency and calibration"
- "+/-1 dB (f < 500 MHz)"

Said in terms of measurement dynamic range (for +/- 1dB accuracy), the manufacturer's spec is 85 dB typical, and 88 dB "maximum". On my beta unit, I found the dynamic measurement range at the calibration frequency (20 MHz for the beta units) to better those specs:

- 77 dB for +/- 0.5 dB (i.e., +/-12% power)
- 92 dB for +/- 0.8 dB (i.e., +/-20% power)
- 93 dB for +/- 1.0 dB (i.e., +/-25% power)

Of course, the manufacturer's specs were over the entire frequency range, which I was unable to measure. I was however, able to measure from 2 to 80 MHz. Over that frequency spread, I observed the dynamic range to be *at least* as good as their specified "typical" measurement dynamic range. In my measurements, I also observed a phenomenon that degraded the low-level accuracy when the frequency was below 2 MHz.

For charts of my actual measurements, and more detailed explanations and observations of the performance tests I did, look -here- for a white paper on that subject.

Mods... *Already?*

The FPM-1 is a compact unit that might lend itself readily to being portable, were it not for two factors. First, no provision is made for an internal battery. The manufacturer recommends no particular power supply, but provides a somewhat standard coaxial DC power jack (5.5 x 2.1mm, I believe), and specifies the power requirements as 9-15 VDC @ 200 mA. I found that a common (and compact) 9-Volt, 300 mA unregulated DC wall-transformer ("wall-wart") powers it quite nicely.

The FPM-1 is chocked full of electronics. As a result, it's a little power-hungry, but it's not quite *that* hungry ;-) During beta testing, I measured current consumption as 110mA @ 9.25 VDC with the LCD's backlight ON, and 55 mA with the backlight OFF. Fortunately, the clever design team at M-Cubed provided a means of turning the backlight OFF by choice or by default (from the factory, it's ON by default).

To make the unit more truly portable, I wanted to add a 9-Volt battery. Even on the bench, I hate having to deal with wall-warts. But I'd also like to be able to carry this instrument to the field. There are two problems regarding a 9-Volt battery:

1. There's no place inside the enclosure to put it;
2. A regular alkaline battery's internal resistance is too high for a 55 mA load, and the voltage would sag below 8 Volts, where operation begins to be affected.

The solution is simple, but maybe not exactly elegant:

1. Put the battery holder outside, attached to the enclosure;
2. Use a rechargeable NiMH battery (the 8.4 Volt type, not the 7.2 Volt type)

I used a holder I got from FRYS (sorry, I forgot to write down the part number), but you can see a picture here:

(click on the above picture to see larger version)

Conclusions

Simple: This is a great kit-building project, and promises to be immensely useful around the shack. I intend for it to get a lot of use.

73, and enjoy!
monty N5ESE

Construction Pictures:

- Unassembled parts, as received
- Main pc board, assembled, component side
- Main pc board, assembled, solder side
- Keypad pc board and display assembly, component side, view 1
- Keypad pc board and display assembly, component side, view 2
- Keypad pc board and display assembly, component side, view 3
- Keypad pc board and display assembly, solder side

- Fitting the Keypad/Display/LED/Switch assembly in front panel
- Board fit check, clamshell open, wiring incomplete
- Complete assembly, sans cover (but shield not yet installed)
- Main pc board installed in enclosure, but keypad/display removed
- Brass coax shield, my beta version
- Brass Coax Shield, sketch
- Complete brass shield asssemblies, view 1
- Complete brass shield asssemblies, view 2

Return to N5ESE home page

Overseer: Monty Northrup ... ... leave e-mail ...

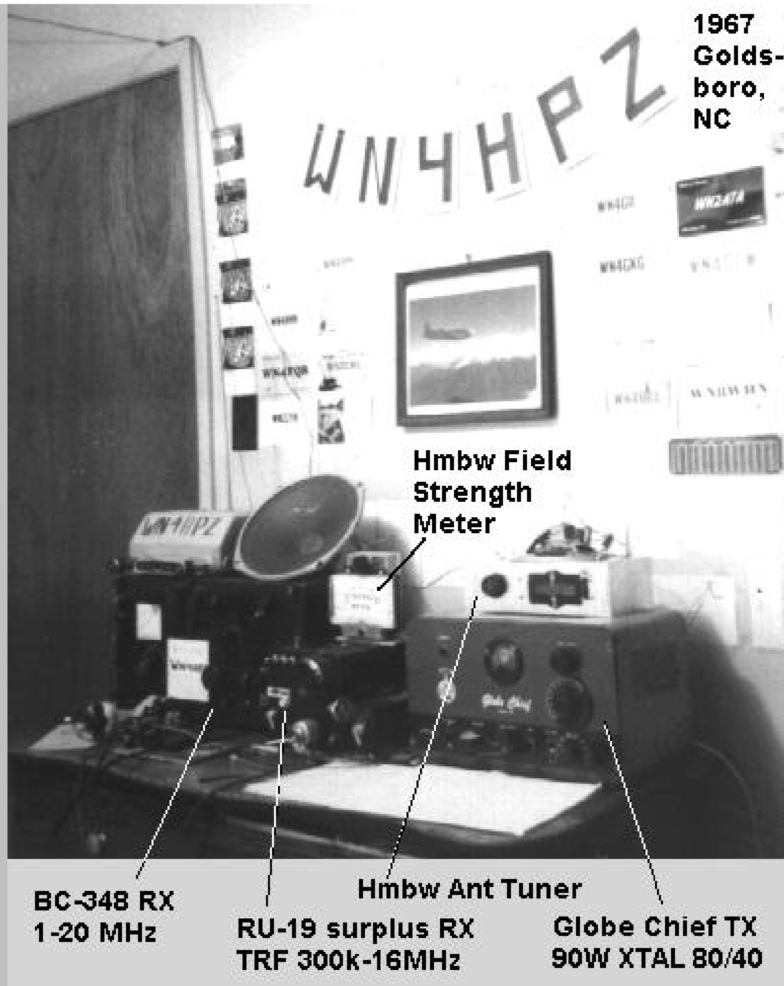
Visit our regular (non-ham, but very popular) homepage

all about Monty, N5ESE

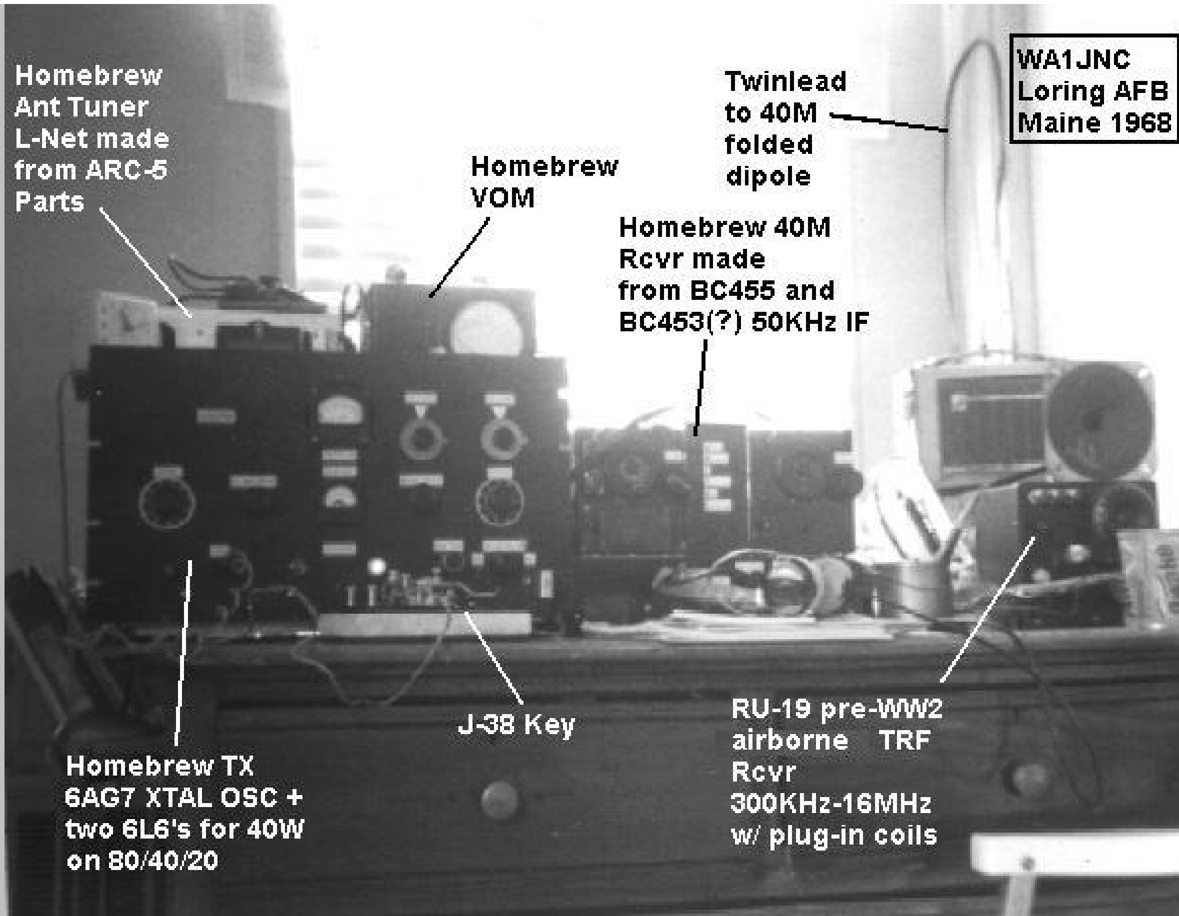
(learn more than you wanna know...)

When I was 14 years old (circa mid 1966) I became friends with "Mike", who at age 18 was eons older and wiser than I, and who just happened to be a very active amateur radio operator. He loved CW and AM, and disdained SSB (saying it would never catch on). His ham shack was a marvel to behold, in a room all its own (he was an only child), with several large receivers, and an ART-13 surplus CW/AM transmitter with motor-driven auto-tuning that was a wonder in itself, with a power supply that weighed twice as much (and it weighed 50+ pounds). I would stay and watch him operate, and it seemed like he could work the world at will. One day I noticed a project, obviously homebrew, mounted on a piece of plywood, and nearly covering the worktable. When I asked him what it was, he glowed as bright as the half-dozen tubes that lit up when he turned it on. Twenty seconds or so later, out spews from the speaker the cracklings and whistles of 40 Meter CW. I was amazed, and at that moment the homebrew bug bit me hard. I was determined to build something myself, and get my ham ticket. So Mike dug into his junk box, generously donating some tubes and tuning capacitors. I had found an article in the "Book of Knowledge" encyclopedia on a one-tube regenerative receiver based on a 6SN7 twin-riode tube, plug-in coils, a lantern battery, and a 90V dry cell. In about a month of weekends, I had it running, along with a CK722 transistor code-practice oscillator, and for the next 4-6 months I listened to and practiced CW every chance I got.

I took my test at the FCC office in Raleigh, NC, and after 8 agonizing weeks, early in 1967, my novice ticket arrived. WN4HPZ... wow, who could ask for a better callsign? While I was waiting, I acquired an RU-19 pre-WW2 TRF-tuned receiver for $20. It was tuned via a 12-foot speedometer-type cable, had gigantic plug-in coil modules, and was broad as a barn. But it had superb audio fidelity and was quite sensitive, so I felt like I was in high ham heaven. I then built a one tube "Cheap and Easy" CW rig from a CQ (I think) article. It was powered directly from the 115V AC line voltage, so it needed no transformer, but you really did have to be very careful not to touch brass while you keyed. Of course, I waited until I had my ticket, and fired it up with a 40 Meter crytsal. It lit up a 7-watt light bulb dummy load quite nicely, so I tranferred it to the long-wire ant I had strung up over the house and back to the basketball goal post. After several fruitless CQ's, I got a call on my landline from my mentor, Mike. Turns out he and his family were watching TV in their home a mile away, and all they could hear was the "clicking" from my new homebrew transmitter. I should QRT immediately, he says, and deal with it tomorrow. The next day, we visited another local ham (call forgotten), an old-timer with a garage full of equipment, and he loaned me a BC-348 receiver and Mike loaned me his Globe Chief transmitter and a handful of crystals to get my station underway. Finally, my first QSO, on 80 Meter CW! I spent every spare moment, til the wee hours of the morning, polishing my CW skills, and filling my log with QSO's. The picture below is of my first station in Goldsboro, N.C .



In the ensuing months, I built (successfully this time) a multiband transmitter, and acquired two WW2 surplus command receivers (BC-455 and BC-453) which were converted to a 40-Meter CW receiver with a tunable IF. My father (who was an NCO in the Air Force), was transferred in January of 1968 to Loring AFB, in the very northern tip of Maine. We had to live on-base, and I could not get on the air until I got permission from the base commander to erect an antenna and operate a radio within the boundaries of the Air Base. This involved submitting drawings of the proposed antenna, and getting it reviewed by the communications officer and the MARS commander, as well as other paperwork. A month later, I was approved and on the air. It was a very interesting experience. 80 Meters CW had been my favorite band in N.C., but it was sometimes difficult making contacts on 80 from way up there, and I shifted my activity to 40 Meters CW. I also upgraded my license from Novice to Conditional (the equivalent of General, but the test was given by a volunteer examiner because I lived more than 300 miles away from the nearest FCC office), and got the call WA1JNC. I acquired an old Vibroplex bug for $7, as my CW was getting fast enough to limit me on the J-38 Straight Key my uncle had given me (which, by the way, I still have). I was immensely popular on the 40 CW band, because I was in a rare state (Maine) and a very rare county (Aroostook County), and county-hunting and W.A.S. were very popular at that time. I did tons of operating, all CW, and mostly ragchewing. My homebrewing took a backseat to operating, because as a teenager I had no money, and there were practically no hams around to mentor (or supply) me. The picture below was my station in Maine, where I operated for about a year.



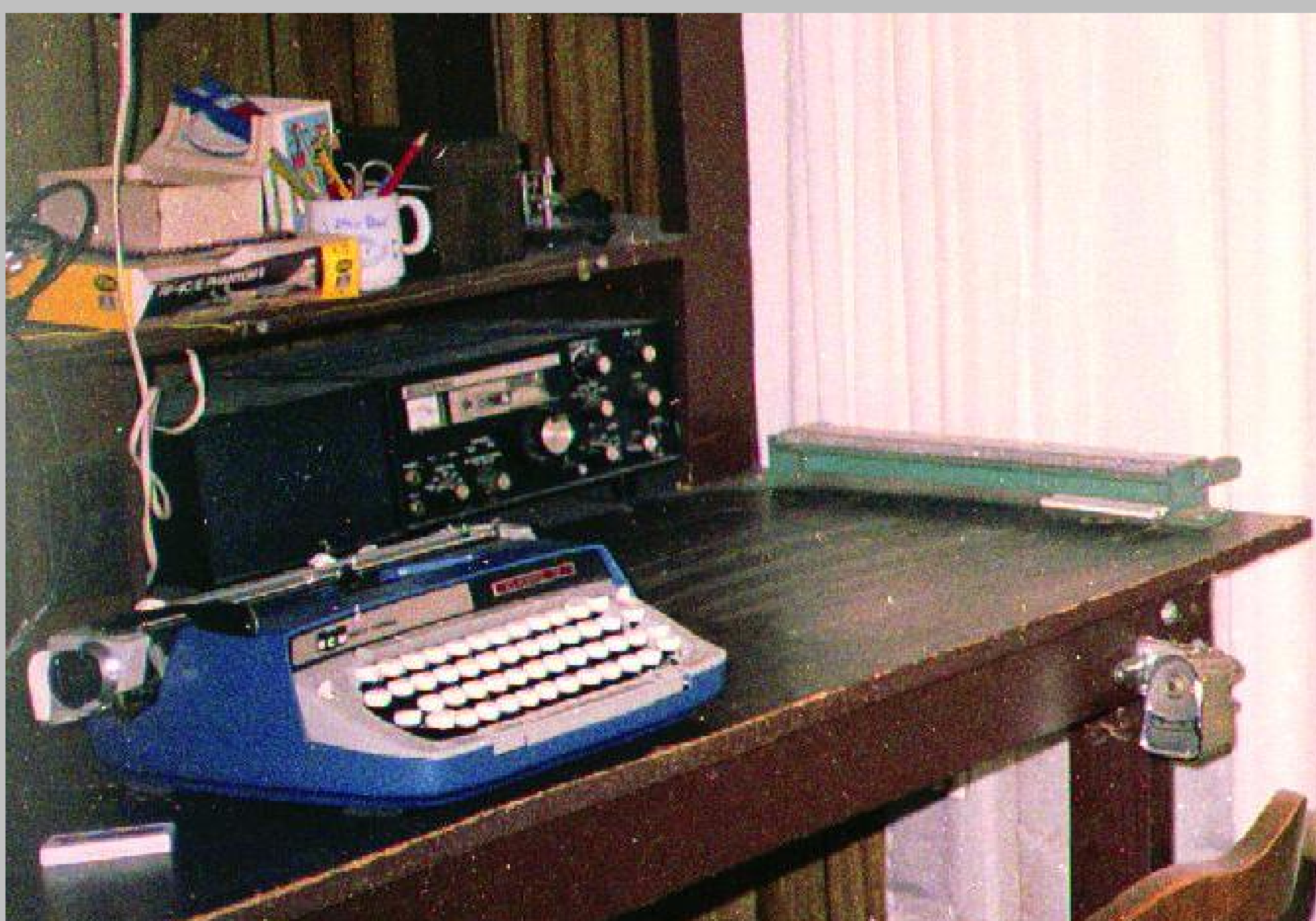
When my father retired from the Air Force in 1969, we moved to Maine, NY (the town of Maine, rather than the state). I once again set up my staion in my bedroom, and joined Air Force MARS, callsign AFB1JNC, operating on the CW net in the 6.9 MHz vicinity. RTTY was already the preferred mode for handling traffic on MARS, but the CW net handled a little bit, and it was good experience in directed nets. As it turned out, the closest MARS station was in Rome, NY, about 90 miles north of me, and so I had little opportunity to acquire free equipment. It was just as well, because I met my future wife in high school, and ham radio took a back burner for quite some time. We were married at age 19 (she was 18), and I never set up my station after moving out of my parent's house. I'm not even sure what happened to all that old equipment.

After my son's birth in 1974, I joined the Air Force for a 6-year stint, and was transferred to Bergstrom AFB in Austin, TX (where I still live). Around '77 or '78, the FCC had instituted "incentive licensing", and would grant a 1X2 call and full operating priveleges to anyone with an Extra-Class license. I had let my ticket expire, and this was all the incentive I needed to get going. But I needed a rig, and so I built the Heathkit HW-7 QRP transceiver. QRP was just becoming popular enough to be commercially viable, and the HW-7 was Heathkit's foray into that marketplace. After a few months of practice and study, I travelled to Brooks AFB to take the FCC- administered tests, and 4-weeks later I received my Extra Class callsign, and my First-Class Radiotelephone License with Radar Endorsement (talk about an albatross!). My assigned call was a KA5-something call, if I remember right, and I hated it, and immediately applied for my 1X2 callsign. About six weeks later, I was issued my callsign, N5FC, which I held until my current call (about 25 years). I did a lot of 40 Meter and 15 Meter QRP CW operating, with great success, in spite of the HW-7, which had a less-than-swell receiver. I build a Heathkit GR-78 shortwave receiver, which actually performed better than the receiver in the HW-7 (I still have the GR-78). I also built a band-switched solid state 15W amplifier (built around a Motorola MRF449 RF power transistor) to get me over the rough spots. At one point, I acquired a Johnson Viking Valiant transmitter (what a boat anchor!) but at 300 Watts CW, I found it scary, and a little too easy. During this time, I and Lew Fay AA5Q (now SK), organized the '79 Spring Eyeball (and a couple of subsequent ones), which met in Fort Worth to allow an opportunity for 30 or so regular 40 Meter CW ops to sit down and chaw eyeball-to-eyeball. Around this time I built the Heathkit HR-1680 Receiver and matching HX-1681 CW Transmitter. This was the best Heathkit pair I'd ever used for CW, with flawless QSK. I recently ran across this picture of me operating in South Austin, using some of this equipment:

At the time this was taken, I had not yet acquired the transmitter of that Heath pair, and was still using the HW-7 and homebrew amp as my TX.

In 1981, I got out of the service, moved across town, and built the Heathkit HW-5400, a synthesized SSB/CW HF transceiver with a solid state final. It wasn't particularly popular among hams, but it did a good job for me for several years. For most of these years, I used a homebrew CW keyboard, built around 4000 series CMOS chips, using a design by a friend of mine, Harry W5DF (now SK). I found years ago that the muscles in my fingers would not go any faster than about 25 wpm (even with an iambic paddle), even though my cw copy speed was in the 40-50 wpm range. Here's a picture of that shack, circa 1982:

Now, here's a mystery, or at least proof of my failing mental condition. Recently, I was scanning some old family negatives, when I ran across a picture of my operating bench, with a rig *I don't remember ever owning or operating*. Haw! Yes, I've totally lost it... but that's my bench and equipment. Trouble is, I can't even identify the rig, and the negative is too grainy to read even the manufacturer on it.



UPDATE: Mystery solved! Ed, K5BOT correctly identifies this as a Tempo One. When he told me that, the neurons started lining up all in a row, and I remembered that I acquired it from the widow of a close friend and a regular on 40M some years back, Lew AA5Q. I also remembered it was one of the worst CW rigs I ever used, and

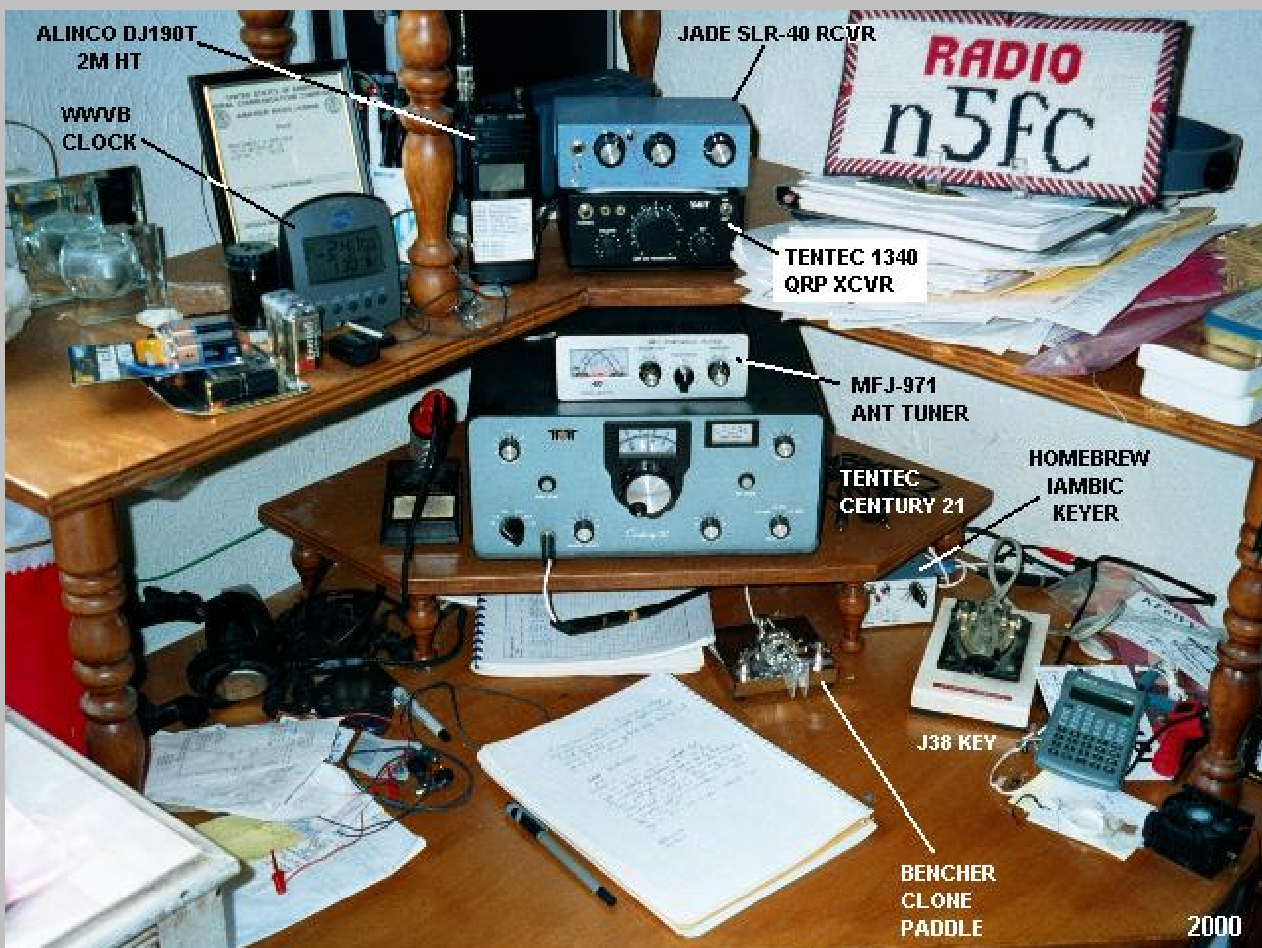
it got maybe one or two days' use before being relegated to the shelf to gather dust. At the time, I didn't even own a mic, so I can't say how it worked on SSB.

But I digress...

In late 1982 my father died, and I launched into a long period of inactivity in ham radio, spending most of my spare time doing volunteer woork for the local hospice organization, and eventually for the Center for Attitudinal Healing. In 1989 I separated from my first wife, and in that process (i.e., starting over) gave away all of my ham gear (all of it!).

Eventually, I re-started in ham radio, purchasing an old Ten Tec Century 21 CW transceiver for my main rig, which still serves that purpose. I also got back into homebrewing, which probably comprises 75% of my current ham activity. Since I was starting from ground zero again, my first project was an iambic keyer, based on HC-series CMOS chips. In 1998 I built the Jade Products SLR-40 receiver kit, so that I could have something to drag around in my suitcase when I travel on business (which is a lot, lately). I was really disappointed in the performance of the shielded antenna that came with the SLR-40 kit, so I built one out of a wooden embroidery hoop, and sticky-backed copper tape. You can see all about my loop antenna -here-.

Below is a semi-recent picture of the operating position at N5FC.

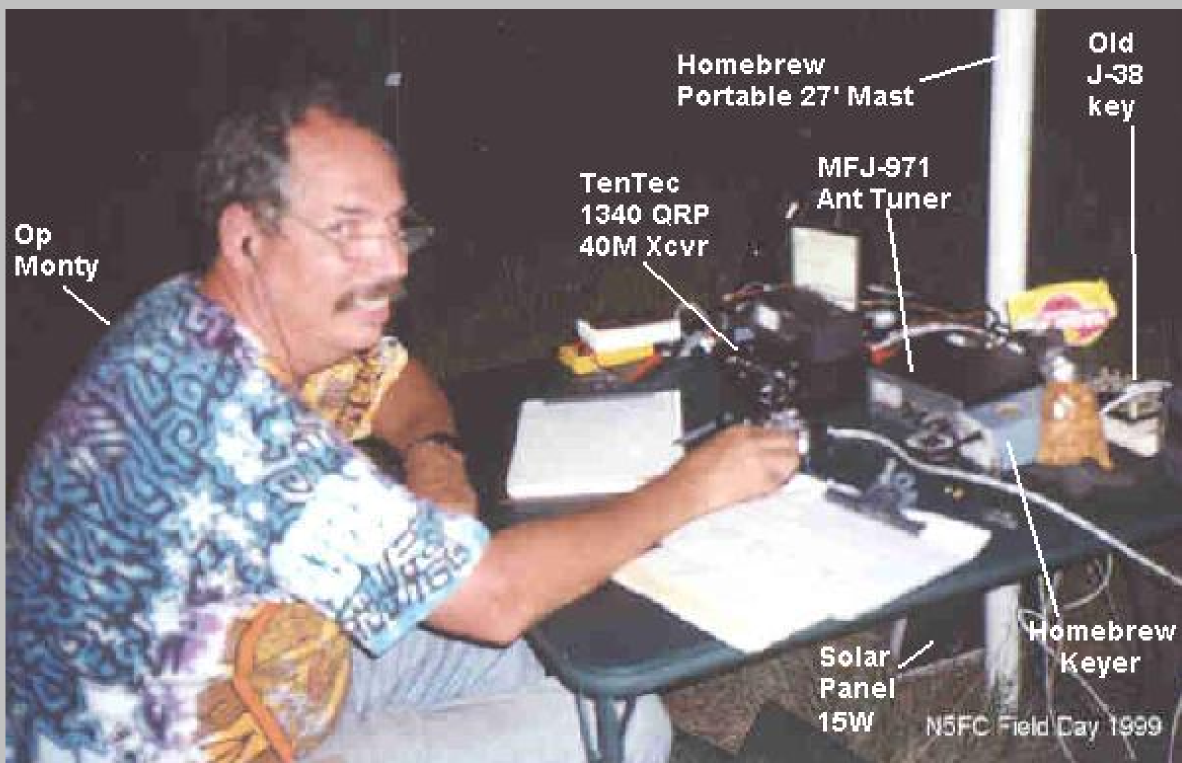


I had big plans to enter the 2N2222 contest in Dayton sevral years ago, but couldn't quite pull it off in time. I still want to build that project (I have the parts in hand), but if you want to get a jump on me, here's the paper design.

In spring of '99, Tech America (now, no more) had a sale in which the Alinco DG-190 2-meter HT was priced below $100. I took this as my cue to get involved in local (Austin) VHF FM, and bought my first microphone in 30+ years as a ham. It's been very interesting to meet local hams on-the-air and in person for the first time, as a result of this activity. Austin has a great bunch of friendly and helpful hams, and a lot of local activities. I also carry the HT on business trips, hooking up to a quater-wave mag mount which I throw on the roof of my rental

car, or use on top of the microwave oven in my hotel room, or with my homebrew portable ground plane. Wanting a little more performance, but not wanting to spend much money, I purchased a Kenwood TM-261A for my car. It has performed superbly. One of my biggest problems with mobile FM for me is concentration while operating while driving. I'm still struggling with that one, so I'm more likely to be listening than talking, although if the traffic is light I will often get on the local 146.94 repeater.

In summer of '99, I participated in Field Day in the single-op single-band QRP class. I only lasted 20 of the 27 hours, but I garnered enough points to have the highest score in my section (for my classification). We went full out, erecting a portable mast and inverted vee for 40 Meters in the early hours of the exercise, and operating only on solar-charged batteries. For my transceiver, I used the Ten Tec 1340, which I had put together in the previous two weekends. With 3 watts out, it did a marvelous job for me, and the receiver was a particularly nice superhet design. Here's a picture taken in the wee hours of the morning, as I made contacts during Field Day:



One of my favorite discoveries is the Austin QRP Club; I've been attending meetings since October '99 and having an absolute ball! And here's a picture of me with some of the guys at one of the AQRP Club meetings. In June of 2000, we participated in field day under the auspices of the Austin QRP Club, using call KQ5RP, and made a pretty decent showing in our class. The location was "secret", but suffice it to say it was primo ham radio territory. Here's a picture of a spectacular sunrise on field day morning: (nuff said?)

click on the image for a larger version

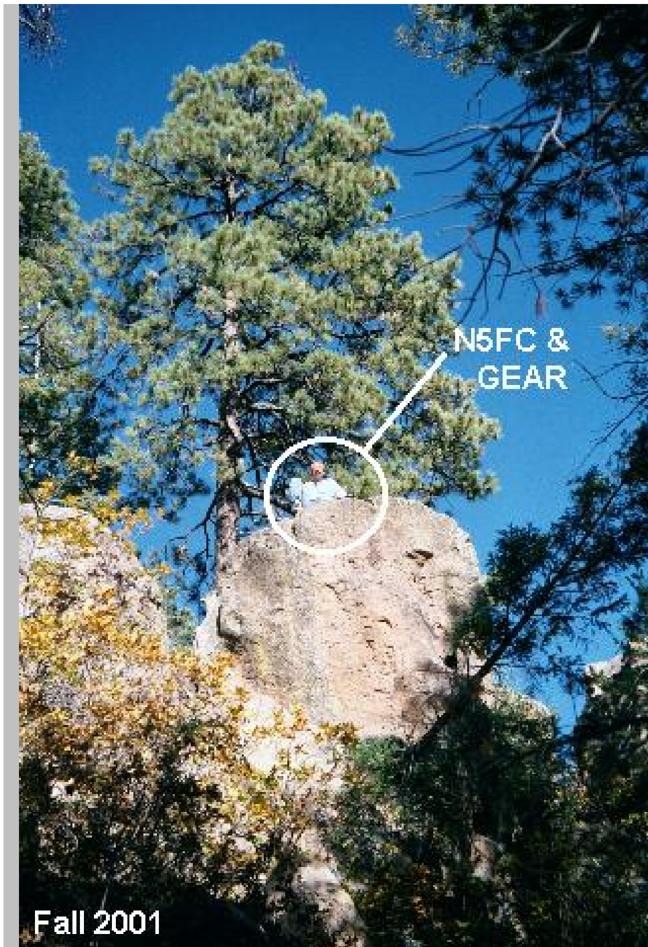
In 1999, via e-bay, I acquired a TenTec 555 Scout SSB/CW transceiver, with plug-in modules for 80, 40 ,30, 20, 15,and 10. It's now my main rig. It has a really hot receiver, with an interestiing and useful "JONES" variable-bandwidth crystal filter. You can see some spectographs of the receiver bandwidth -here-. At 2.5" x 7.25" x 9.75", it's also very small, can be operated at 5 W or 50 W and highly portable (though it's somewhat of a power-hog). I modified it to switch at will between QRP and 50 watts, which makes it great for QRP and portable ops. I occasionally pack it in my suitcase for business trips, and operate off a 7 AH gel-cell battery.

Here's a recent picture of the shack, which occupies one corner of the master bedroom... click on the image for an annotated version detailing the equipment shown. Some of my recent projects can be seen in the stack of equipment. OK, OK... I ain't known for being neat (the XYL reminds me all the time).

click on the image for a larger version

Field Day 2001 with the Austin QRP Club was great fun; we were foiled by lightning for a while, and had to abandon ship for several hours, hurting our score, but it was great fun nonetheless. Here's a picture of me at the paddles with N5WU's K2 (what a great QRP rig!)

Field Day got me spun-up for portable ops, and since then I've spent more time operating portable outdoors than I have operating from home. Here's a picture, taken by my wife Carolyn, of me operating from a unique location in the mountains of northern New Mexico.



click on the image for a larger version

On this particular outing, I was able to work a JA for about 15 minutes, using about 2 watts from my TenTec 1315 transceiver on internal batteries, with an RFD antenna. He was also at a high altitude (around 9000 feet), and commented that we might be line-of-sight HI HI.

In June of 2002, I built the Elecraft K1 CW transceiver. With 4 bands and a built-in Automatic Antenna Tuner and internal battery set, I found myself itching to be in the field more and more. In the following picture, you can see how self-contained the unit is... even the Palm Mini-Paddle mounts to the side of the K1.


click on either image for a larger version

Above right, you'll see a picture of one such outing, during the Adventure Radio Society's "Flight of the Bumblebees" QRP contest in 2002. Let it be said right here that I am no contester. In fact, my bumblings during this contest earned me the distinctively low honor of being nominated and unanimously accepted into the Second-

Class-Operators Club. Somebody said it was because I was calling "CQ BB" for hours on the day *before* the contest... NAW! I didn't do that, did I?

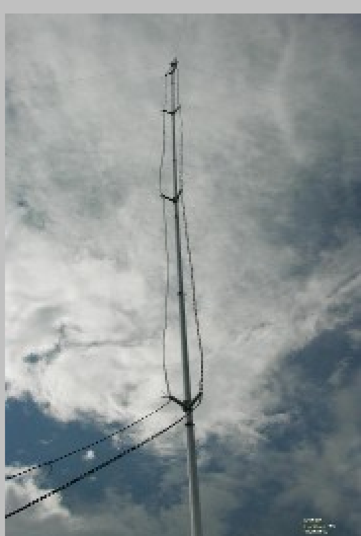
In December of 2002 I ran into Lloyd, K3ESE, a fellow QRPer, and we had a grand ragchew, talking about our experiences with our respective K1s and Rock-Mites. But what made this QSO so unique, and surprised me as much, was the amount of fun I had sending his "shave-and-a-hair-cut" call. I was so enamored, I actually looked to see if 'N5ESE' was available in the Vanity Call System. Lo and behold, surprise of surprises, it was! And on Jan 3, 2003, I gave up my dear, longtime, cherished 1x2 callsign N5FC, and acquired my new baby, N5ESE. (I hope I haven't done something rash... but it won't be the first time...)

I continue to build radio gear all the time, and typically get on-the-air only once-a-week or so. My current (and maybe oldest) homebrew project is the 2N2222 transceiver. It's about 2/3 complete, and so far about 25 transistors (all '2222's of course)... keep your eyes peeled on this site for pictures and schematics...

Lately, in large part because the Elecraft K1 and KD1JV's AT-Sprint make it so easy, I've done a lot of portable QRP operation. In fact, in the past year and a half, I've logged more Q's from the field than from home. I don't document all my trips, but if I get pix, I try to post my most recent one -here-. QRP ops have become a favorite pastime, and if I'm not using the K1, I'm using the AT-Sprint 3-bander in conjunction with a pocket-sized Elecraft T1 Automatic Antenna Tuner. I'm a big fan of compact, elegant designs, and these definitely fit the bill. They also make getting on the air anywhere you go about as easy as it can be.

During Austin Summerfest 2003's QRP Forum, the Austin QRP Club, spearheaded by Glen Reid K5FX, surprised me with a public presentation of a trophy, which you can see -here-. Thanks, y'all.

In the summer of 2004, after years of lusting, I built the Elecraft K2, just in time for Field Day. Impressive receiver. Most recently, I added the Audio DSP board option, which is pretty impressive (especially so for reduction of man-made noise). I also added the SSB board, though my intention is to use it on PSK31, as I'm not crazy about phone ops.



In April of 2007, the XYL and I moved out of the city and into the boonies of Central Texas. It's quite an adjustment after 30+years living around interminable power line hash noise (and being unable to work 80 Meters), to living in an earea where the noise is almost completely dictated by atmospheric conditions and weather. To top it off, we have a little acreage, and for the first time in my life I can put up a hellaciously long wire antenna if I have the inclination to. Right now (2008), I have two crossed doublets at 40 feet, each fed independently with 300-ohm ladder line. One is 350 feet long, and the other 88 feet long. What a luxury!

Unfortunately, between work and yard maintenance - I was totally unprepared for the amount of effort keeping up 4 acres is - I have little time for home-based operating. To illustrate this point, here, after over a year, is how much

progress I've made getting the ham shack unpacked:

Now, don't feel too sorry for me. I still get a good deal of operating in. As a result of the move, I have a 50-60 minute commute to and from work in Austin. That's nearly 2 hours of mostly free time to play radio every workday. So nearly every day, Monday through Friday, you'll hear me (propagation gods willing) on 40, 30, or 20M. Even though I start every QSO at QRP 5 Watts, using only a mag-mounted mobile dummy load (hamstick) on my big clunker Oldsmodbile, it's amazing that I get 2 or 3 QSOs on almost every trip, and typically one of those will be a ragchew! Ain't radio mysteriously, wonderfully fun? Here's my typical /M setup:


If you're interested in a QSO with me, here's my current modus operandi: I usually start on the QRP frequency of the highest frequency open HF band, and work my way down (to the next band) as conditions permit. Usually, on my morning commute from 7-8 AM (Central Time), I'll be found calling CQ (and signing /QRP/M) on 10112, 10106, or 10122. Calling CQ while QRP has some operating advantages while /M. First, the other operator can decide whether he wants to deal with the QRP signals, given the current band conditions. Thus, everyone who calls is a willing participant. Secondly, it requires less interaction on the driver's part with the radio controls, leaving the attention on the road, where it must of needs be.

My return trip could be anywhere in the time frame 6-9 PM, and during that trip home I'll try to work the highest band which is still open.

Feel free also to fire off an e-mail to me, and request a CW sked 160-10M. We'll do our best to accommodate you.

73,
monty N5ESE
dit dididit dit

Overseer: Monty Northrup ... ... leave e-mail ...

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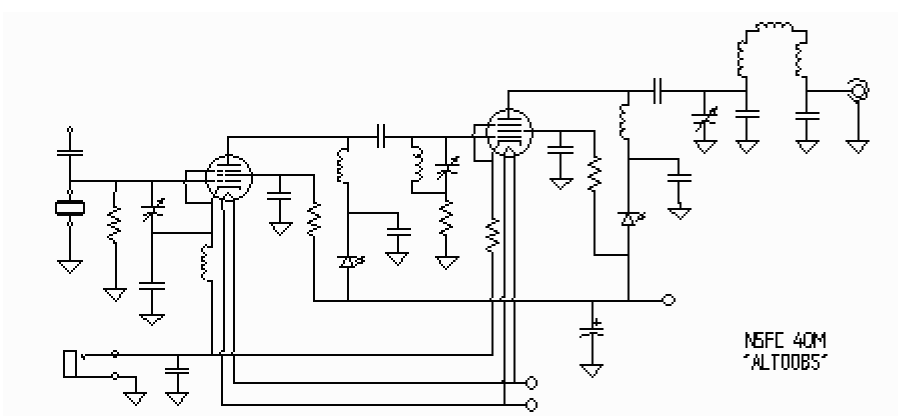
N5ESE's
"Altoobs"
2-Tube 40 Meter CW Transmitter

(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

My homebrew projects tend to progress in stages, spread over time. This one was certainly an example of that process. Being enamored of projects built into the ubiquitous Altoids tin, I decided I wanted to see if I could package a two-tube crystal-controlled transmitter onto one of these boxes. I began thinking about it about 3 years prior, sketched out a paper design six months later, acquired tubes about a year ago, and finally put solder to it last month. I decided to name it "Altoobs", a play on the tradename "Altoids".

As you can see from the schematic below, there is nothing unique about the circuitry in this two-tube 40-Mter crystal-controlled transmitter. In fact, it's fairly "cookbook", using a pentode-based colpitts crystal oscillator, followed by a beam-power-pentode final amplifier with pi-output network, all cathode-keyed.



(click on above image to see larger image with component details)

We selected a 12BY7 as the oscillator tube. The functional characteristics of the 9-pin miniature 12BY7 are nearly identical to the old metal 6AG7 which was popularly used as a crystal oscillator in 50's and 60's novice transmitters. To keep things small, we use a 7.040 MHz crystal in a modern HC-49 holder. This was also the reason we used a separate oscillator and amplifier. The oscillator would not have to run so much current (to deliver power to an antenna load), and so we stand less chance of damaging our crystal (modern crystals are smaller and more susceptable to damage by excess current than ye oldf FT-243's).

We departed conventional wisdom in selecting a final amplifier, because almost all the popularly-used tubes required plate and screen voltages of 250 V or more (usually. more). The 7551 was a special-purpose VHF class-C amplifier tube, most often used in industrial/police service in commercial mobile radio gear in the 60's. Packaged in a 9-pin minature tube, it was capable of 10 watts output at 30 MHz, with 250 V plate supply, and has a 12.6 V filament. [FWIW, the 7558 is an identical tube with 6.3 V filament, and can do the same job]. We designed our output circuit for a plate impedance of 3000-ohms, transforming 3000-ohms to 50 at the antenna port. At 150 Volts of B+, then, we might expect a plate current of about 25 mA, and a DC power input of 3.75 watts, nominally. With a projected efficiency of 60%, we should manage something around 2 watts output. The 7551 is not actally characterized for operation at less than 250 V plate and screen, but it's plate curves show significant plate current at 150 Volts and lower, so we will assume it will do something useful with a 150 Volt supply. By the way, we could get a full QRP gallon (5 watts) by running a plate voltage of 225 VDC, but we'll forego the extra power in deference to simplicity, compactness, and reduced stress on the components.

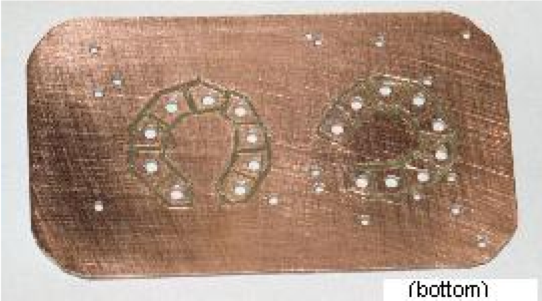
To reduce component count and eliminate one power supply voltage, we opted to use cathode keying. With a grid cutoff voltage of somewhere around 20-25 volts, and total (V1 + V2) cathode currents of less than 50 or 60 mA, we should even be able to use our modern solid-state keyer.

In order to package all this circuitry (sans the tubes) into an Altoids box, we needed to deviate from traditional tube construction protocols. First, we decided to use toroid cores instead of air-wound coils in all tuned circuits, as air-wound coils are just too big. And instead of the classic pi-net with variable capacitors for tuning and loading, we decided on a fixed-loaded pi-net, designed to load a 50-ohm antenna. This is quite reasonable in this day and time when almost all solid-state rigs are designed for fixed 50-ohm outputs. If we need further matching, we'll accomplish that with an external antenna tuner. In lieu of meters for plate current indicators, we decided to try LEDs, which are considerably more compact. Finally, in an effort to keep components small, we'll plan for a plate voltage of 150 V. This means we can use regular 1/4 watt resistors, and small-package capacitors. The lower B+ voltage means our final won't put out quite as much power as the tube is capable of, but if we can get 2 watts out, we'll be happy. Of course, the lower plate voltage also simplifies power supply design, keeping the cost and size of that to a minimum. [You can see our power supply -here-]

A printed circuit was used to mount circuitry. I prefer the old "cut-and-peel" method, utilizing a hobby knife to remove unwanted copper and form islands.

Caution! When using a hobby knife, *always* wear safety goggles!

We used a double-sided board, cut to "just fit" inside the Altoids tin. We used the bottom side as ground plane, and drilled holes as required. We obtained pc-mount 9-pin ceramic sockets, mounting them through the board, and soldering the pins on both sides. Components were mounted "surface mount" style, on the top of the board, which is also the circuit-side. This board ain't pretty, but it does the job:



(click on either image above to see a larger version)

Below is a picture of the pcb, populated:

(click on the image above to see a larger, annotated version)

From the picture, you'll notice a few unusual things. The toroidal cores are wound with kynar-insulated wire-wrap wire. Enameled wire probably should not be used, because the insulation will likely breakdown between the core and the wire. Also, the large red LED, rated at 60 mA, was intended to be a plate current indicator for the final amplifier. I say intended because although it works, it's very hard to quantify the current. We kept it because it makes a cool blinking light as you key, and is a good confidence indicator for plate current. The smaller LED, rated at 20 mA, performs the same function for the plate circuit of the oscillator.

Notice that there are three variable capacitors, of the 8 mm poly-insulated trimmer type. The one nearest the crystal allows the crystal frequency to be adjusted somewhat. Adjust this one for minimum chirp and drift (there won't be much, regardless of setting).. The other two adjust the final amplifier's grid and plate tanks, respectively.

The completed pcb is mounted inside the Altoids box using three 1/4" high aluminum spacers and appropriate hardware. B+ voltage and filament voltage are brought into the box through rubber grommets in the lower back (behind the cover hinge), via pigtails that connect to binding posts on the power supply.. Shorter pigtails, terminated with an appropriate connector, provide for antenna connection and key line input. Holes are drilled in the hinged cover of the Altoids box to allow for mounting of the two tubes, for access to the trimmer capacitors, and to allow the LEDs to been seen. Here's a picture with the cover open (with an output older filter section in it):

We fabricated a label for the cover, which you can (mostly) see below:

(click on the image above to see a larger, annotated version)

Below is a picture showing a complete working setup. The gray box on the left is our homebrew [145 V Regulated Power Supply], which also supplies the 12 V filament voltage. In spite of being fairly compact, the power supply, with it's two transformers, is considerably larger and heavier than the transmitter. The antenna cable, which exits the Altoobs chassis on the lower left, is connected to our homebrew [dummy load]. And a J-38 keys our transmitter. By the way, I was also able to directly key the Altoobs using our homebrew [CMOS Keyer] and the [K1EL Keyboard].

(click on the image above to see a larger, annotated version)

For those who might want to duplicate the Altoobs, please refer -here- for additional construction and tune-up notes, in an Acrobat-format (.pdf) printable file.

Our first QSO with the Altoobs, yielded a distance of 817 miles (Austin, TX to Atlanta, GA), a 549 report, and a good 35 minute ragchew with with Jim, AD4J.

Enjoy, good luck, and 73!
monty N5ESE

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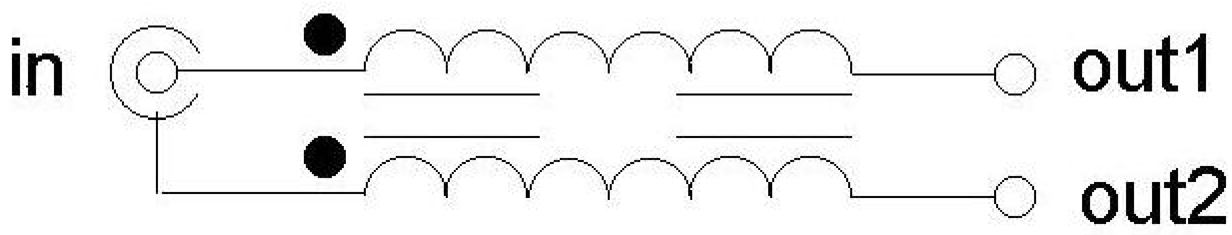
N5ESE's 1:1 Current Balun

(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

Here's another handy little Altoids QRP project. For Field Day 2002, I wanted to use my new Elecraft K1 (which has an automatic antenna tuner built-in) to feed a full-wave loop on 40 meters, to use on all bands 40 - 15. To preserve the feedline balance (I used 300-ohm ladder line), I needed a balun at the output of the K1's antenna tuner. This 1:1 balun did the trick quite nicely.

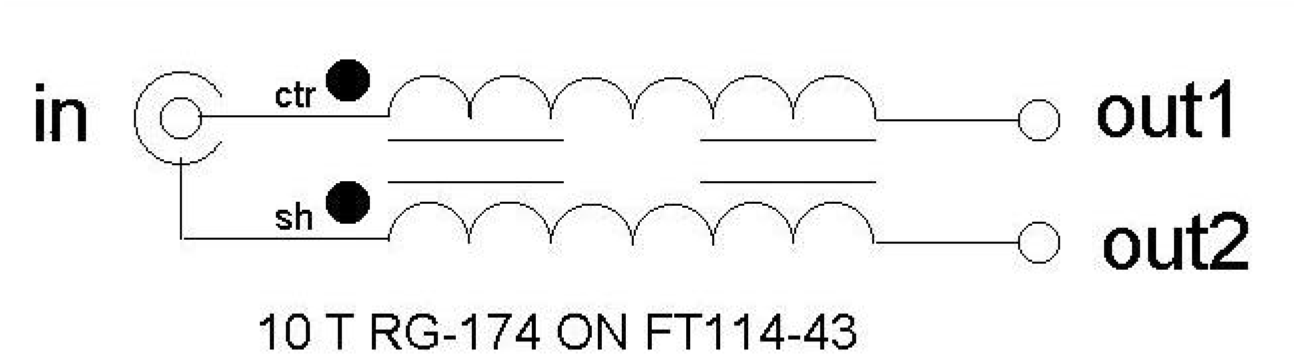
The classic 1:1 current balun's circuit looks like so:

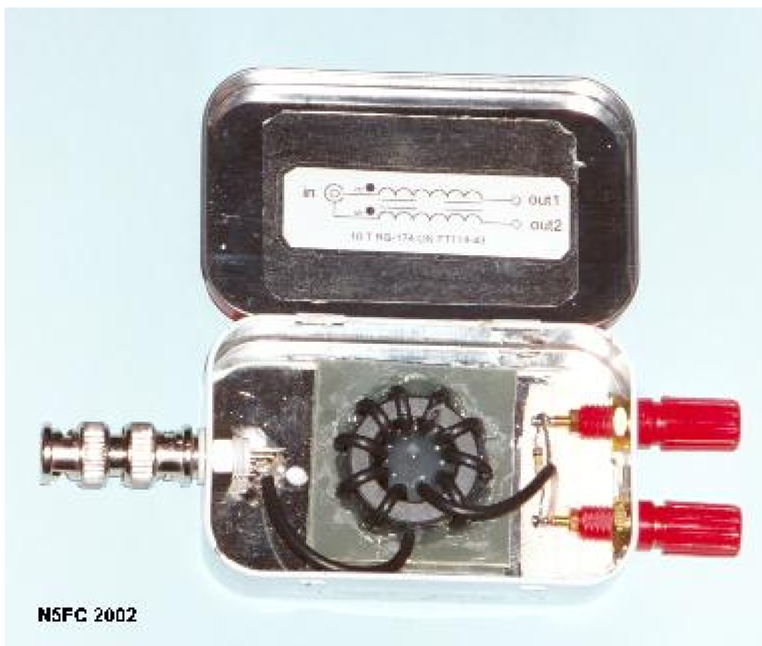


Two versions were built. The first was wound with 16 turns of side-by-side AWG 20 teflon-coated wire onto a FT114-43 core. It is shown below:

(click on the picture to see larger version)

It did a marvelous job on Field day, but subsequent measurements using my MFJ Antenna Analyzer showed that the SWR rose gradually from 1.1:1 at 21 MHz to 1.8:1 at 30 MHz (into a 50-ohm dummy load). I felt I could do better, using small-diameter coax instead of parallel pairs, and this proved to be true, yielding 1.05:1 at 21 MHz and only 1.15:1 at 30 MHz. Below are the schematic and picture of the coax-wound version, using 10 turns of RG-174 mini-coax:





(click on the picture to see larger version)

For a close-up view of the toroid winding and connections on the coax-wound version, click -here-

Construction-wise, on both versions, an isolated BNC is used at the input (Amphenol 31-010), though a garden variety BNC connector (non-isolated) mounted directly to the Altoids box could as easily been used. I grabbed a piece of 3/32" thick PC board that I had laying around as scrap, peeled off the copper, and used that as the "mounting plate", mounting the completed toroid with hot glue. This gave the coil a little clearance from the Altoids case's metal, hopefully minimizing distributed capacitance. Then, standard banana plug binding posts were used for connecting the feedline to the balumn's output. Though not shown in the schematic, two 100K resistors are added , one on each output terminal to case ground (or just one between the two output binding posts), to bleed static charges (it is assumed that the transceiver or antenna tuner will be earth-grounded).

In operation, a female-to-female BNC adapter is mounted on the BNC jack of the balun, and the balun is then mounted directly onto the BNC jack on the rear of the transceiver or antenna tuner. Alternatively, mount the balun at the feedpoint (assuming the feedpoint is 25-100 ohms, and feed using a half-wavelength of coax). While throughput losses were not measured, it can be assumed that the balun will be lossy for impedances much above or below the intended matching range (25 - 100 ohms), or outside the intended frequency range (1-30 MHz).

Also, I believe the balun is readily usable at 10 watts applied power, but that it may be good to somewhat higher levels. Use at higher levels has not been analyzed nor tested.

This balun lives in my QRP travel kit, and gets lots of field use.

To see a 1:4 step-up current balun, go -here-

73,
monty N5ESE

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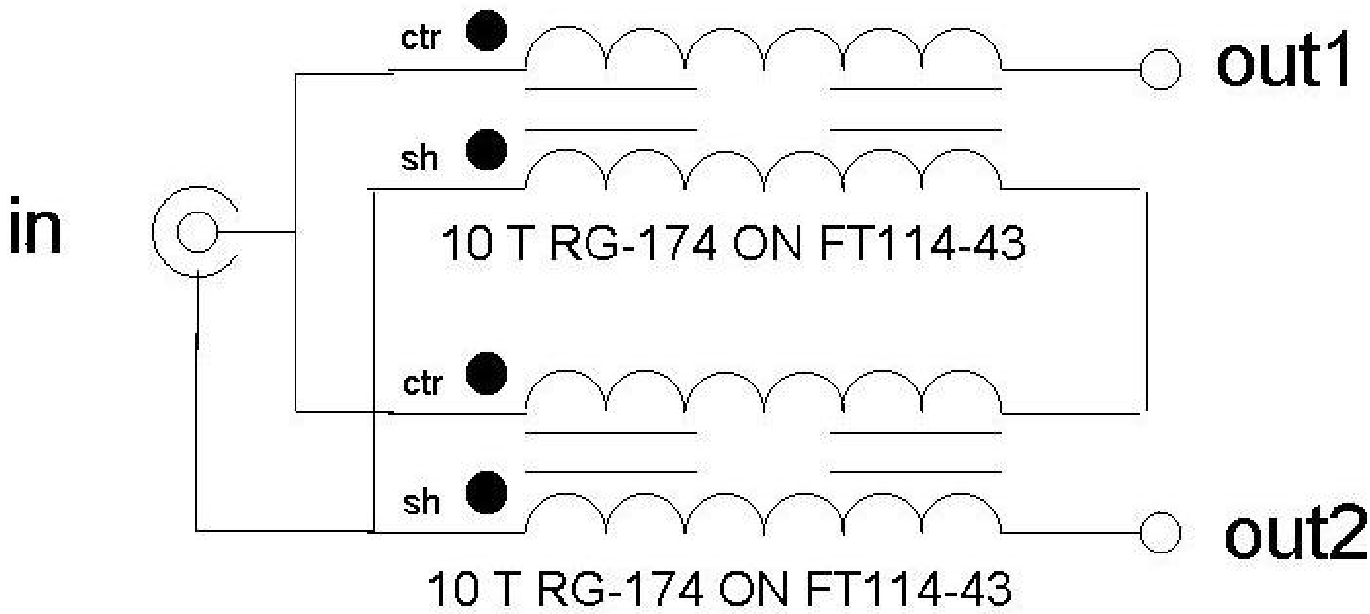
N5ESE's 1:4 Current Balun

(click on any picture to see larger version)

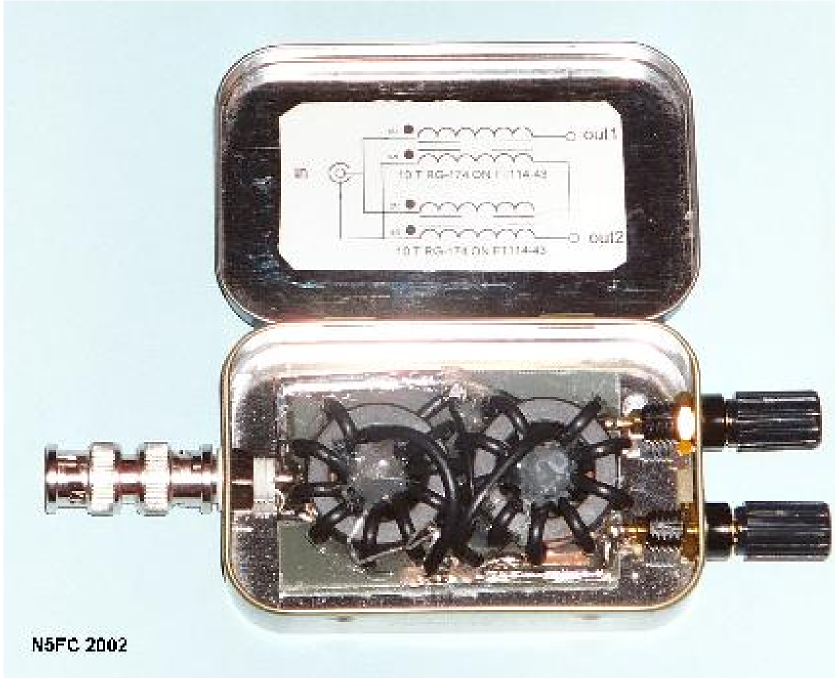
NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

Here's yet another handy little Altoids QRP project. This makes a great travel companion to the 1:1 current balun (described -here-), and is intended to aid in tuning a balanced antenna or feedline that has a high impedance (100-600 ohms). I've even used it successfully to tune a 20 meter, 1/2-wave vertical with 4 radials, placing it directly at the bottom feedpoint of the vertical, feeding it with 50-ohm line (RG-58), and letting my Elecraft K1's automatic antenna tuner do the rest.

The classic 1:4 current balun's circuit looks like so:



This version, shown below, is wound with 10 turns of RG-174 mini-coax on each of two FT114-43 ferrite cores.



(click on the picture to see larger version)

Measurements using my MFJ Antenna Analyzer showed that the SWR rose gradually from 1.1:1 at 21 MHz to 1.25:1 at 30 MHz (into a 200-ohm dummy load).

For a close-up view of the toroid windings and connections on this version, click -here-

Construction-wise, an isolated BNC is used at the input (Amphenol 31-010), though a garden variety BNC connector (non-isolated) mounted directly to the Altoids box could as easily been used. I grabbed a piece of 3/32" thick PC board that I had laying around as scrap, peeled off most of the copper, but left some copper traces to ease wiring. The PCB would also serve as the "mounting plate", mounting the completed toroids with hot glue. To preserve balance, attention is given to keeping all lead lengths symmetrical; that is, all the leads on toroid 1 are identical to toroid 2, and the length of the wire from any junction to the input and the output connectors, is identical for both toroids. Standard banana plug binding posts were used for connecting the feedline to the balun's output. It is assumed that the transceiver or antenna tuner will be earth-grounded, to provide a path for bleeding static charges on the antenna.

In operation, a female-to-female BNC adapter is mounted on the BNC jack of the balun, and the balun is then mounted directly onto the BNC jack on the rear of the transceiver or antenna tuner. Alternatively, mount the balun at the feedpoint (assuming the feedpoint is 100-400 ohms), and feed using a half-wavelength of coax. While throughput losses were not measured, it can be assumed that the balun will be lossy for impedances much above or below the intended matching range (100-600 ohms), or outside the intended frequency range (1-30 MHz). Also, I believe the balun is readily usable at 10 watts applied power, but that it may be good to somewhat higher levels. Use at higher levels has not been analyzed nor tested.

I used this balun between my K1 and 1/2-wave vertical to help match the antenna. Without it, the K1's automatic antenna tuner could not find a match below 5:1. With the 1:4 step-up balun, the K1 managed a 1:1 match, and 30 QRP contacts were made in dreadful band conditions during the 2002 Flight-of-the-Bumblebees contest, with contacts up and down both coasts. Needless to say, this balun is a keeper.

To see a 1:1 current balun, go -here-

73,
monty N5ESE

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N5ESE's 25 Watt Dummy Load

(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

The "dummy load" is an indespensible accessory for any radio amateur. Using a dummy load, transmitter adjustments can be made "off-the-air" so that no unnecessary interference is generated on the ham bands. And dummy loads are an easy useful project that just about anyone with moderate soldering skills can build.

The one described here can be used for up to 35 watts for short transmissions, and up to 25 watts for longer periods. It presents a 50-ohm load (or something very close to it) from DC to well over 30 MHz. Because it is rated for low-power operation, it makes an ideal dummy load for the QRP operator.

WARNING!

Dummy loads dissipate energy by generating heat. Heat generated in a small space translates to temperature rise, and temperatures can be hot enough (under the right circumstances) to burn people and ignite adjacent materials. Because of the thermal mass of the dummy load and its enclosure, that heat can stay around for a long time. Always locate your dummy load in a safe place, where there is no chance that it will burn people or catch something on fire.

A dummy load is basicly a resistor, designed specifically to dissipate RF energy that would normally go to an antenna. Dummy loads are usually 50-ohms, although there is no reason why you can't build one at 75-ohms, or 300-ohms using the same techniques. Not just any resistor will do; a wire-wound resistor will have way too much inductance for use at HF frequencies (even the "non-inductive" kind). Metal-film, thick-film, carbon-composition, metal-oxide film and carbon-film resistors are generally good candiadtes for HF dummy loads. You can buy resistors specifically made for high power and RF, but they are very expensive. Or you can take the approach shown here, and use LOTS of commonly available resistors in parallel to form a single resistor functionally

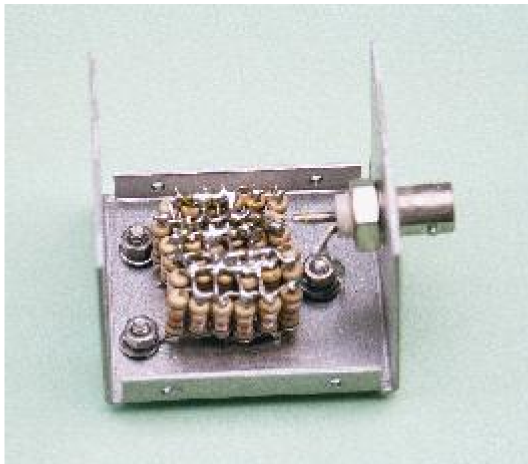
When you join equal-value resistors in parallel, two beneficial things happen:

1. the overall resistance decreases by a factor of "n", that is the final resistance R = R/n
2. the overall power dissipating ability goes up (but not necessarily by a factor of "n")

Knowing this, I went a-hunting at my local electronics outlet. I went looking for 1 or 2-watt carbon resistors, which are usually dirt-cheap. I had a big selection to choose from, and I ended up picking up 36 each 1800-ohm 1-watt 5% carbon-film resistors, at 5-cents each (oh, wow... almost $2). Using our formula, 1800 / 36 = 50-

ohms... perfect! When constructed, these resistors will dissipate 36 watts safely for a short period of time (say 10-30 seconds), but will need a long cooling-off period after that. If I limit the power to half of that (i.e., 17 watts or less), I can probably key-down for much longer periods (but read the "WARNING!", above). At QRP levels of 5-watts or less, I can leave this keyed continually, with plenty of margin.

While I was at the candy store, I picked up a UG-1094 panel-mounted BNC jack, and a small aluminum project box, 2 x 2 x 2-inches. WARNING! plastic is NOT suitable as a construction material for dummy loads, and may even be dangerous, should it melt or ignite!



Click on the image above to see a larger, more readable image

As you can see from the image above, I arranged six resistors in a row, routing the lead of the first to the second, and soldering it, and the second to the thrird, etc... on both ends. I ended up with 6 rows of 6 resistors, and soldered those in parallel, too. I left 3 leads on one side, which I formed into a "ring" terminal, which (in conjunction with 3 screws and 3 nuts) served to mount the resistor assembly to the inside of the enclosure. The other side gets wired to the center conductor of the BNC jack. Grabbing my trusty ohmmeter, I measured 49.7-ohms (plenty close-enough).

How well did it work? Well, on the HF bands, with 25-watts of RF, I read a 1:1 SWR, even on 10-meters (30-MHz). On 2-meters (146 MHz), it reads about 1.3:1.

Don't be afraid to substitute different value resistors. Using the right number of EQUAL-VALUE resistors, you should be able to build a usable dummy load at any impedance from 25 ohms to 1000 ohms, and 5 watts to 100 watts (or more). Keep the peak voltages to less than 200 volts (Voltage = square-root of Power * Resistance). Use a shielded enclosure, possibly ventilated with holes to release heat. Be aware of heat dissipation (ever touch a 25-watt bulb?), and plan for it. The amount of power applied must never exceed the aggregate ratings of the resistors, and probably should be kept to something much less, depending on your enclosure and how well heat is released.

73,
monty N5ESE

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N5ESE's 40 dB Tap Attenuator

(click on any picture to see larger version)

In recent years, we've seen great advances in monolithic semiconductor detectors built for receive (RSSI Detectors) and transmit power detection. Some examples are: the Analog Devices AD8307 and AD 8362, and the Linear Technologies LTC5507. These devices have a string of high-bandwidth logarithmic amplifiers followed by a highly compensated detector with unprecedented overall measurement accuracy of up to +/- 0.5 dB (about 10% of the power) over a range covering audio to 500 MHz or even higher. And that, over a measurement range from picowatts to milliwatts. Try to do that with your 1N34 !

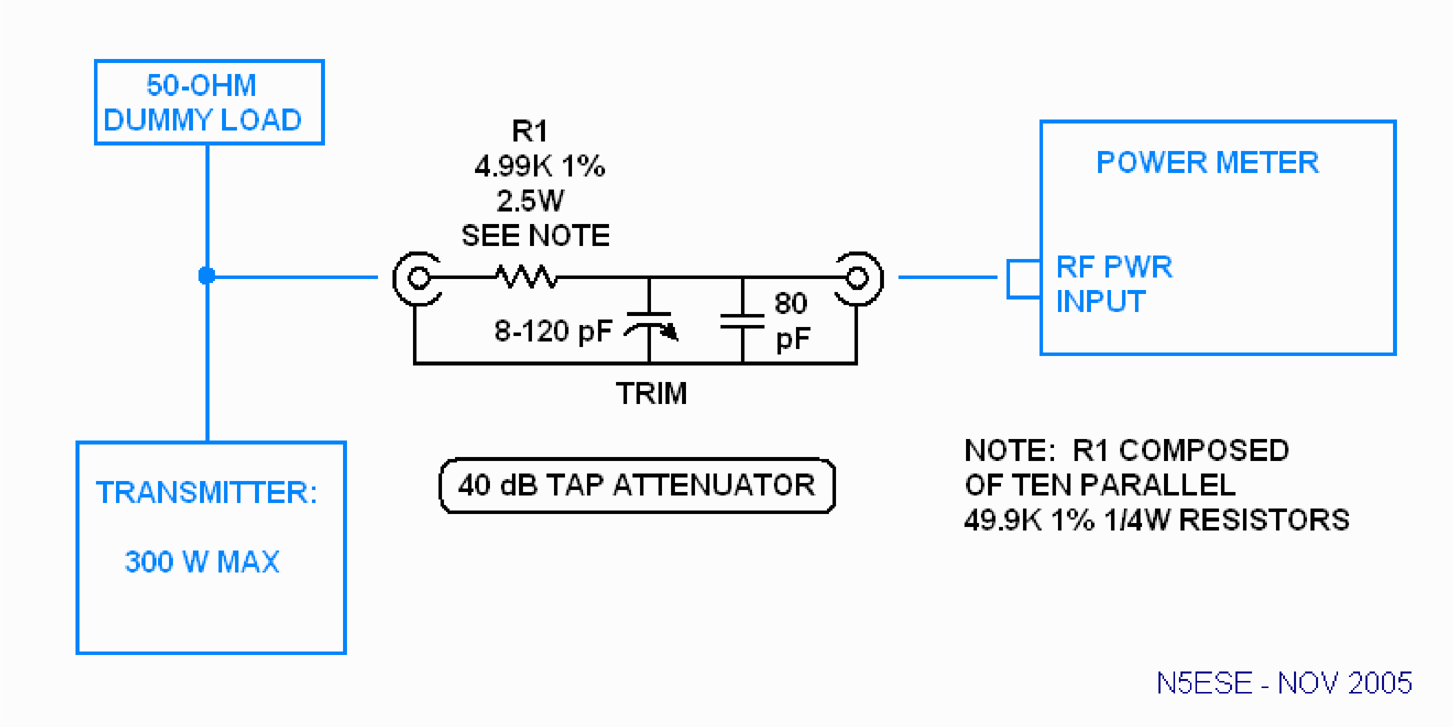
Being able to accurately measure RF circuitry down into the milliwatt range is amazingly useful for those of us who "homebrew" radio gear, or who operate QRPp (output power in the sub-watt range). But nearly all of us venture above the 10 milliwatt level, and it would be really, really nice to extend the measurement accuracies we see with these new chips, up into the watts and hundreds-of-watts range.

What I describe here is an accurate 40 dB (power factor of 10000) tap attenuator, usable with 50-ohm matched circuits, which will allow you to extend the measurement range of the newer RF power detector chips to around 100-350 watts (depending on the chip's upper measurement limit). Useful upper frequency limit is something near or over 220 MHz (but I've only verified it to 148 MHz).

What's a "Tap" Attenuator?

The **tap attenuator** differs from an **inline attenuator** in a couple of ways: Inline attenuators must absorb large amounts of power. A 40 dB **inline attenuator** with 200 watts applied to its input must be capable of dissipating 199.98 watts (!), while accurately delivering only 0.02 watts to the power meter's 50-ohm input sensor. This is actually quite hard to do, because of the difficulty in maintaining accurate resistances with the component heating that necessarily takes place. As a homebrew project, an inline attenuator with this capability can be a frustrating, time-consuming, and expensive task. By contrast, a 40 dB **tap attenuator** need only dissipate 2.3 watts, while delivering the same 0.02 watts to the input sensor. And it's quite do-able.

Let's look a a schematic for a 40 dB tap attenuator:



On the left, we see a typical test setup for a ham transmitter. It could as easily be any other source (an RF driver or predriver stage being homebrewed, for example). The transmitter feeds a 50-ohm dummy load (dry dummy, Cantenna, bank of resistors), which acts as the stable load for the transmitter. The dummy load is important, because it absorbs the power coming from the transmitter, without radiating. We could also use a radiating antenna as the load provided that it is matched and looks like 50-ohms resistive. That would be the case at the input side of a properly adjusted manual or automatic antenna tuner.

One method of measuring power on such a setup would be to use a diode detector (like our own RF Probe project), and compute the power using the formula E * E / R, where E is the RMS Voltage across the dummy load, and R is 50 ohms. This actually works quite well, as long as you have several volts, and you don't exceed the diode's voltage rating. But those two restrictions make it a difficult task to accurately measure powers much below 1 watt or much above 25 Watts. The modern RF Power chip, however, with the proper attenuator to isolate it, can easily measure from nanowatts or microwatts up to 100, 200, 300 or more watts.

But back to the schematic. As you can see, we've inserted a "TEE" connector into the line running from the transmitter to the dummy load. This forms an electrical junction where we'll attach our "Tap" attenuator. This is the point where we would measure voltage if we were using an RF probe. Instead, the tap attenuator forms a **voltage divider** consisting of R1 (ideally 4950 ohms) and the RF Power Meter Input's 50-ohm load. The voltage at the RF Power Meter's input is then 1/100 of the voltage at the dummy load. The tap alters the dummy load's nominal 50-ohms by a minute but negligible amount (49.5 ohms instead of 50 ohms), which can be ignored. Since we know the voltage (at the Power Meter) to be 1/100th of the voltage at the dummy load, we also know that the power at that sensor load will be 1/10000 (i.e., E * E / R) of the power at the main dummy load. That's -40 dB (i.e., 10 log 0.0001)

There's just a wee bit of a twist we must deal with, with this kind of attenuator. If there is some stray capacitance between the TEE junction and the Power Meter's input, it will tend to shunt higher frequencies ***around*** the tap resistor, R1. The effect is that more voltage will be delivered to the Power Meter Input as the frequency increases, making the meter read high at high frequencies. To compensate for that stray capacitance, we add a capacitor in shunt with the Power Meter input. That capacitor forms an RF volatge divider (with the stray capacitance), maintaining the same 1/100 voltage division that the resistors do. Unfortunately, we can't perfectly predict what the stray capacitance is, so we have to make that added capacitor a trimmer-type. During alignment, we'll tweak it so that it reads properly at high frequencies, thus flattening our curve so that we end up with a good broadband attenuator.

If you want to learn more about the operation and limits of the 40 dB tap attenuator, from a theoretical and practical point-of-view, I've written a white paper relating my experiences with SPICE simulations and component calculations, and you can see that -here-.

OK, So Let's Build One!

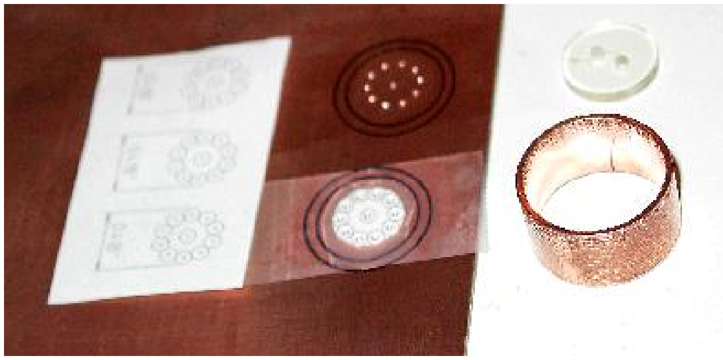
For some reason known only to my deviant Id, I like to build dummy loads and attenuators into copper pipes, and radios into Altoids tins. (it's a sickness...). That's the approach we'll take here. Except for the 3 plumbing pieces (3/4" pipe hardware: 2 end caps, and a repair coupling), which I bought from Home Depot for about $4, everything came from my junkbox. The number and combination of resistors was selected based on what was available. As long as your resistor combination is reasonably close to 4950 ohms, and will safely dissipate 1/100th of the full power to be applied, and you use resistors with good RF properties (metal film, thick film, carbon film, carbon composition, metal-oxide resistors), you should be OK.

I think pictures say a thousand words, so we'll show the assembly step-by-step, and hope it makes sense. Click on any picture, you'll get a larger image **with text annotations** that may make things clearer.

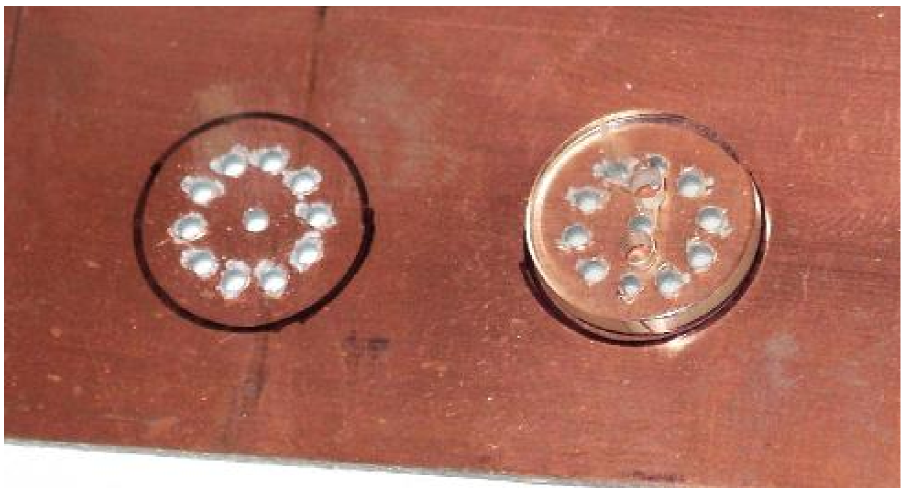
To make room for the internal assemblies, we need to cut down the end caps, using a pipe cutter. When done, the part which slips into the pipe is about 1/4" long (see above).

Then we insert the end caps in both sides of the coupler (it should be a slip fit), and carefully mark, punch, and drill a small pilot hole (one on each end). Then, remove the end caps, debur, and drill and tap the holes for 4-40 screws. On the shield (formerly, pipe coupler), drill two holes (one on each end) to clear 4-40 screws.

Next, very carefully find the center of the end cap, and drill a 3/8" hole to mount the BNC jack. In one end cap, mount a BNC jack with no ground lug, relying on the mounting hardware for connection to ground. This will be the transmitter end. On the other end cap, mount a BNC Jack with a solder lug and hardware. The solder lug will be needed later. Note: good ground/shield conductivity is important for proper performance of the tap... make sure you have good electrical and mechanical connections from the BNC to ground and lug.



We're going to fabricate two small pc boards for mounting the resistors, and we'll use brute-force methods. Take any available double-sided copper clad board, and mark two circles, using the inside diameter of the discarded piece of the end cap. Then take a button (or other suitable object), and mark an inner circle. The inner circle should mark about 1/16" insulating space within the outer circle. I made a full scale template for marking hole centers, based on ten 1/4-watt resistors. I then aligned it carefully within the marked inner circles, and center punched the resistor pads and center hole.



Next step is to drill the center punched holes. I used a 0.050" drill, and it might have been a little large. 0.035" would have been a better fit for the resistor leads. The center hole on one PCB should be drilled to about 3/32" inch diameter, and on the other to about 1/4 inch diameter. Also, flip the board over to the unmarked side (after you've drilled it), and using the button you used earlier to mark the inside hole, mark a circle over both drilled patterns.

Now (back to the first side), use whatever suitable cutting tool you have to cut the two PCB's on the OUTER circles. I used a nibbling tool, and then filed the rough edges smoothly round by hand (see Warning below!). The finished board was about 3/4" in diameter. Now, remember the inner circle? and the one marked on the other side? Using a hobby knife (see Warning below!), and score a circle on both sides of each PCB where you marked the circle. Then peel the copper off, forming a copper-less ring about 1/16" wide around the outer edge on both sides.

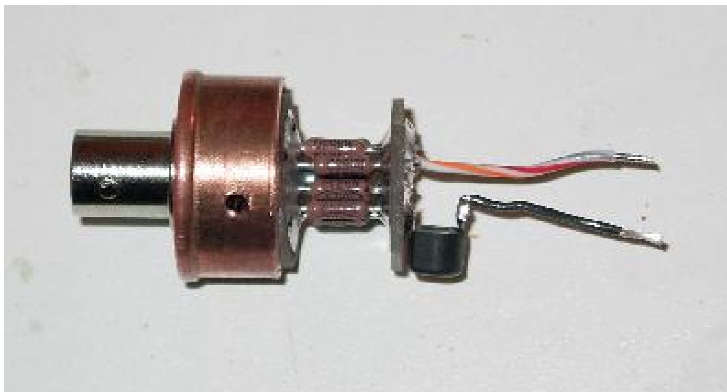
WARNINGS!
1. Fiberglas dust (from filing and cuttng operations on printed circuit board materials) are hazardous to your health if breathed in. Use a dust mask, or otherwise make sure the particles do not become airborne (difficult to do). Also, protect others in the area.
2. Hobby knife blades are prone to breaking, especially at their tips, and can become projectiles with unpredictable paths. Don't risk your eyes! WEAR Eye Protection! Also, protect others in the area.

At this point, the drilled holes are pretty raw, and the PCB may be somewhat tarnished. To remove drill burrs, I take a slightly larger drill bit, and using just two fingers and very light pressure, twist the bit to remove burrs. Then, remove and oxidation on the PCBs (both sides). My favorite way to do this is with a green 3M scrubbing pad. When you're done, the PCB's should be bright and shiny. Lightly coat both sides of the board with electrical grade flux. I like the Kester 186 Flux pen (shown above). Costs about $4 but lasts for years and years.

Now comes the tricky part: installing the resistors. Install all ten resistors into one board first, soldering on both sides, and keeping the resistor body about 1/16 inch from the board. Then, stagger-cut the free leads, and install the other board, again soldering each resistor on both sides, and leaving the 1/16" spacing. When finished, both boards should be reasonably parallel, and each resistor lead should have two solder joints. See above

Now, slip the smaller hole of the resistor assembly over the center-pin of the BNC on the transmitter end (the end with no ground lug). Solder the PCB to the center post (a little flux may help). The larger hole will provide access to the solder post for your soldering iron tip. Make a strong solder joint here.

Grab the end cap that has the BNC jack with the solder lug. Install the 82 pF capacitor between the solder lug ground and the BNC center pin, tucking the capacitor down inside the end cap. Solder just one side lightly, so as to keep the part in place, because we have more connections to these points later.



Find the end cap with the resistor assmbly, and install the trimmer cap by soldering one leg to the resistor PCB. Position the trimcap so that it's trimming screw will point radially outward, and will still fit within the shield (pipe coupling) when it is mounted later. To the other electrical terminal of the trimcap (sometimes it is opposite, sometimes at 90 degrees), attach a 1-inch piece of stranded hook-up wire. Teflon insulation wire with a small diameter and high strand count is preferred for flexibility, but use what you can get. Then, attach a similar piece of wire to the resistor PCB itself.

Without hooking up the wire, fit the resistor assembly into the shield (pipe coupling), and screw it in place. Leave the other end cap unconnected, and carefully measure and mark (on the shield) where to drill the access hole for the trimmer. Then, remove the shield, center punch the mark, and drill an appropriate hole (roughly 1/8").

Reassemble the shield to the resistor assembly, screwing it together. Check the trimmer access hole alignment, Solder the two wires as follows: wire from trimcap goes to ground lug; wire from resistor PCB goes to center pin. Make sure both the wires and the 82 pF capacitor (you mounted earlier) have good, clean solder joints. At this point, your assembly should look as above, just before closing it up.

Close up the assembly, screwing the end caps securely to the shield. Admire your work, which should look something like the above image.

To use the tap, you'll need a BNC-TEE adapter, and a BNC female coupling adapter. It's important for proper operation that the minimum length be used from the tap assembly to the measuring instrument, and from the tap assembly to the transmitter feedline, and the adapters help accomplish that. Both adapters can often be obtained from your local Radio Shack, or your favorite online electronic distributor.

Above, is a picture of the connections to the Power Meter and the dummy load. The dummy load shown is one of my QRP gizmo projects, which you can see [-here-](). You could as easily use your 250 watt dry or wet dummy load. I prefer to have the TEE connected right at the dummy load, where the load impedance is (presumably) 50-ohms. But if that's not possible, anywhere along a matched 50-ohm feedline should work OK.

Finally, let's see the tap attenuator in operation. Above, you can see it measuring the output power on my Elecraft K2, and the power meter is indicating 5.01 watts on 40 Meters. Don't look at the clutter all around it... yes... I know... I'm a slob...

73, and enjoy!
monty N5ESE

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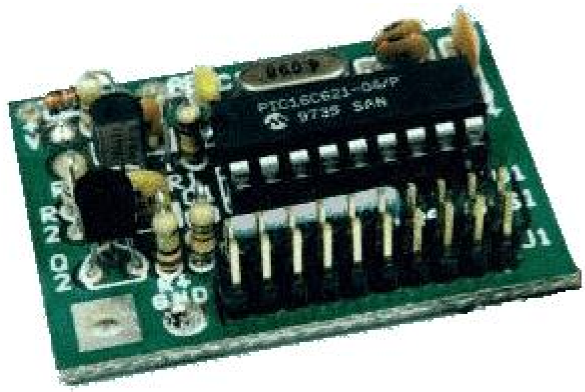
N5ESE's Apps for the SWL Freq-Mite



(click on any picture to see larger version)

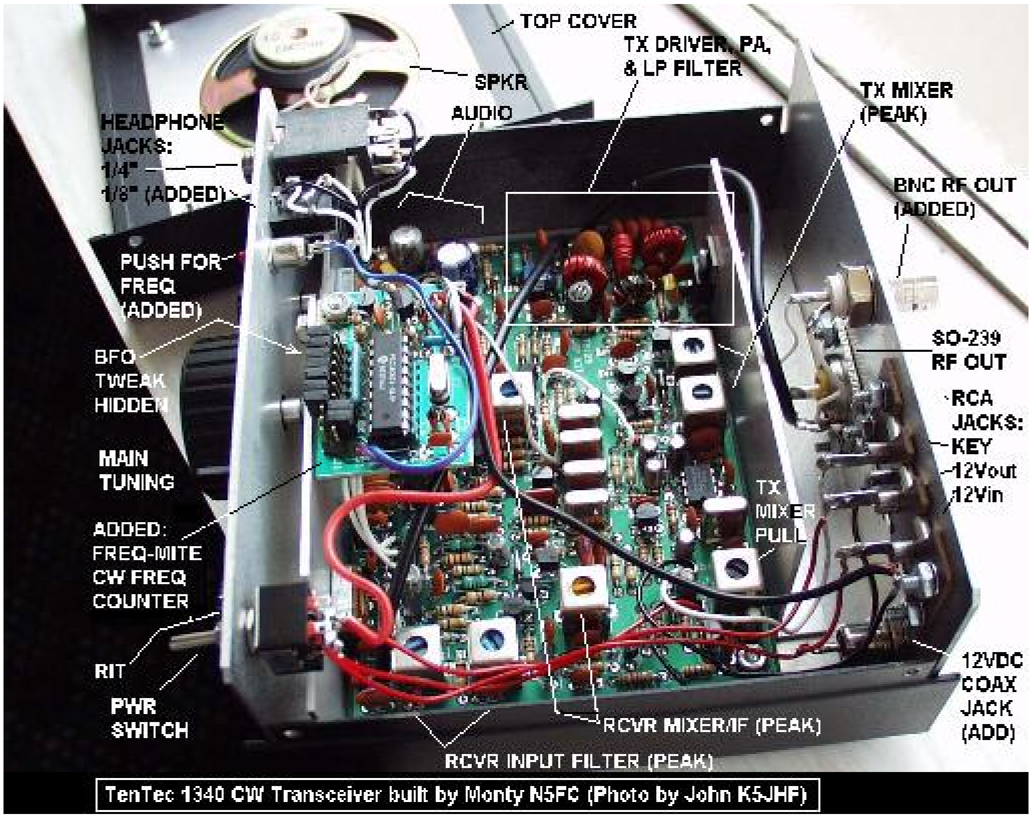
NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

At only $20, the Small Wonders Labs Freq-Mite has got to be one of the kit-building bargains of the decade! This tiny PCB, powered by a PIC microprocessor, will serve as a general purpose RF frequency counter up to 32 MHz. Instead of visual displays, the device provides frequency readings on push-button command, announcing the frequency with 1 KHz resolution in CW... yes, CW! In addition to serving as a general purpose counter, a switch-settable offset frequency can be programmed to allow using it as a "digital-display" counter on your favorite "analog-dial" receiver, transmitter, or transceiver.

I've used this device several times, and I'll probably use it many more. This page will detail three such applications.

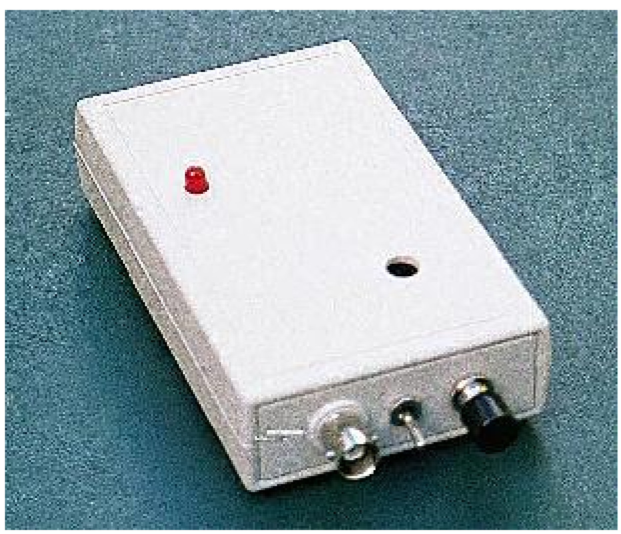
Digital VFO for the Ten-Tec 1340 QRP transceiver:

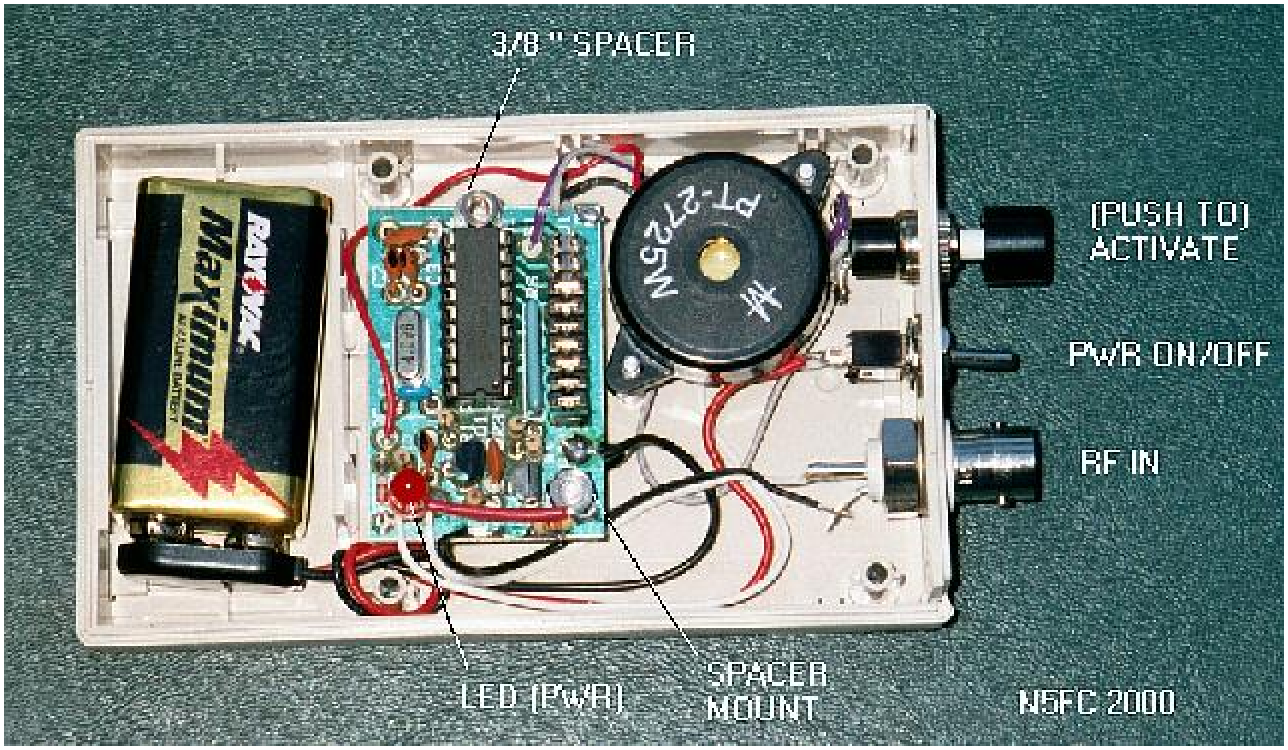
(narrative under construction, but here are some pix:)

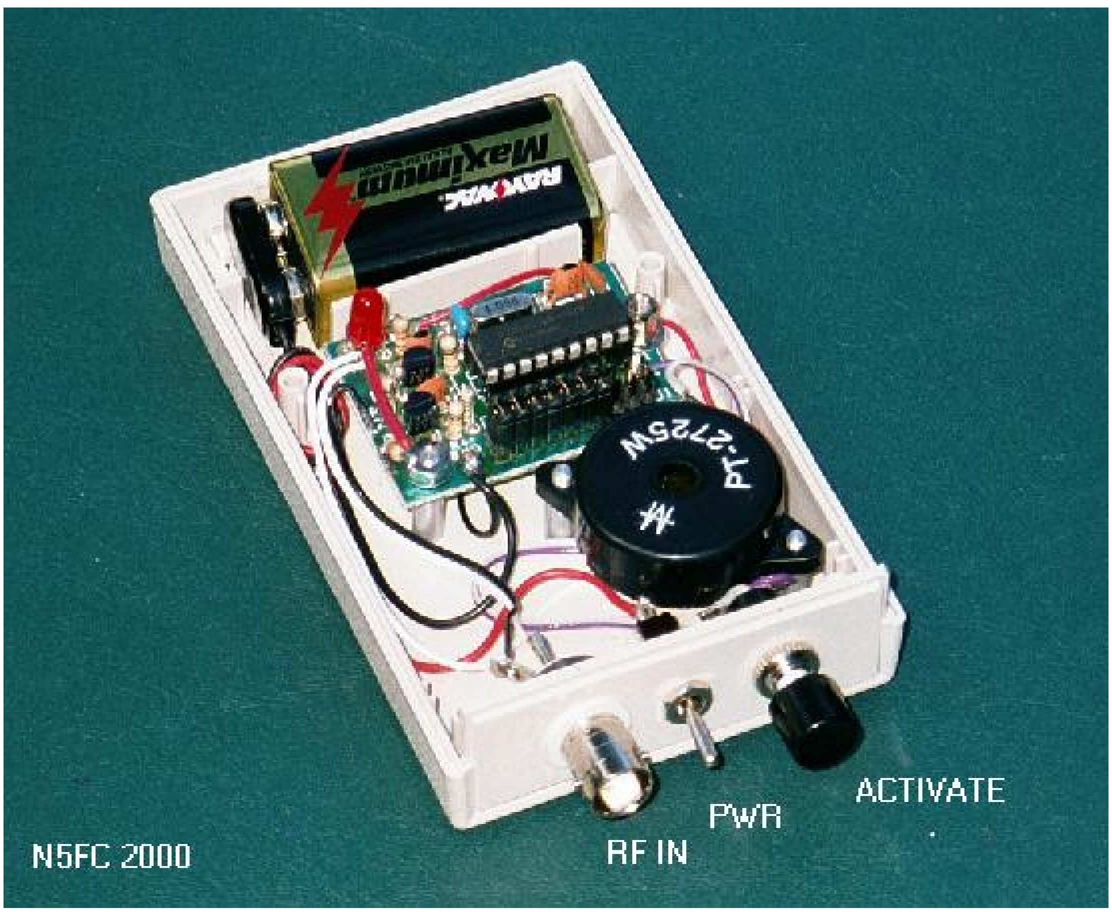


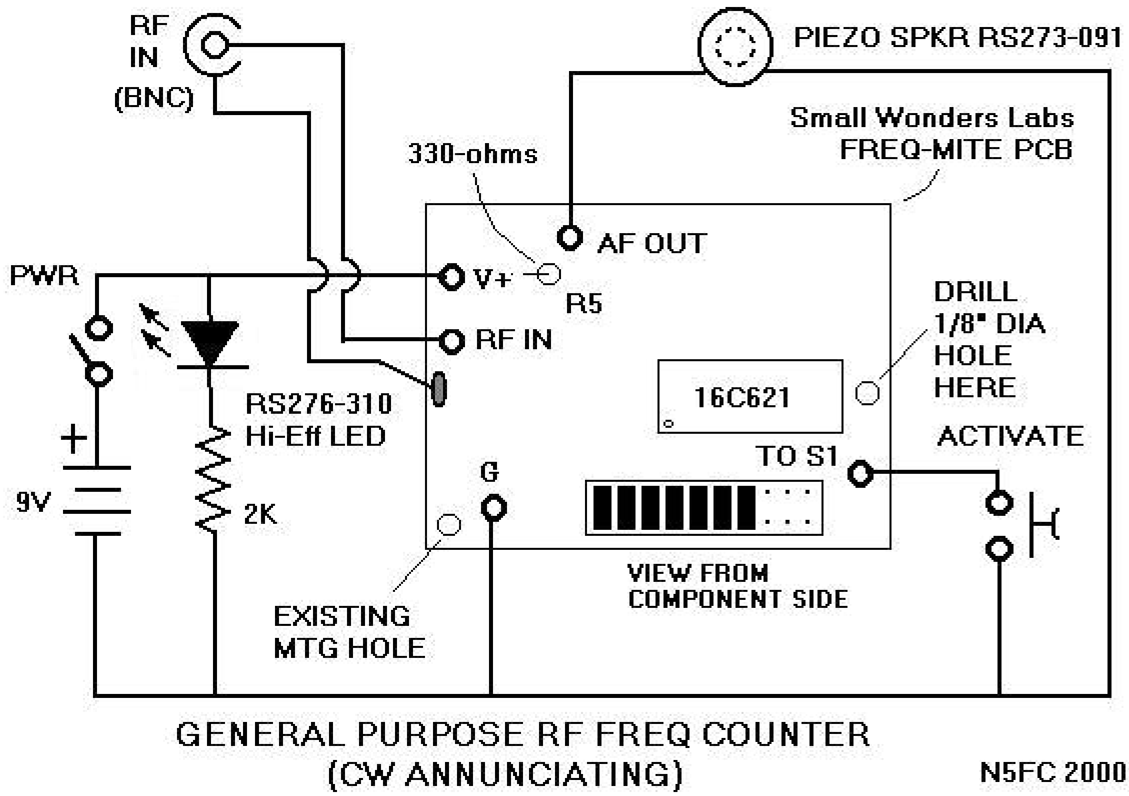
General Purpose Pocket Frequency Counter:

(narrative under construction, but here are some pix:)



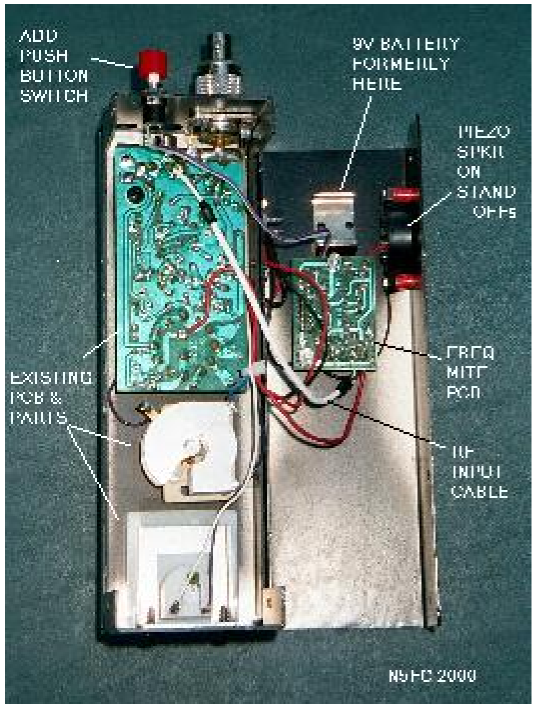

3/8 " SPACER
(PUSH TO) ACTIVATE
PWR ON/OFF
RF IN
LED (PWR)
SPACER MOUNT
N5FC 2000


ACTIVATE
PWR
RF IN
N5FC 2000



Digital Counter for the MFJ-207 Analog SWR Analyzer:

(narrative under construction, but here are some pix:)



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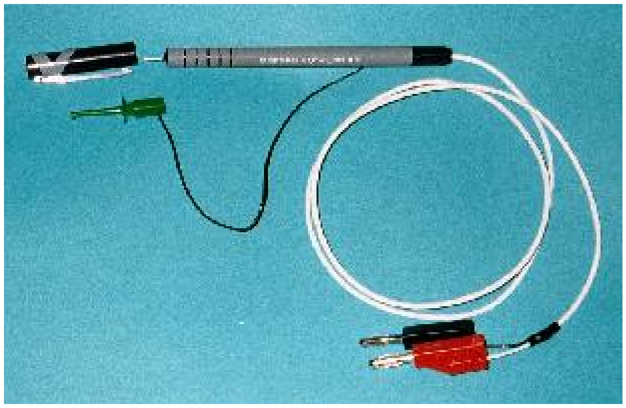
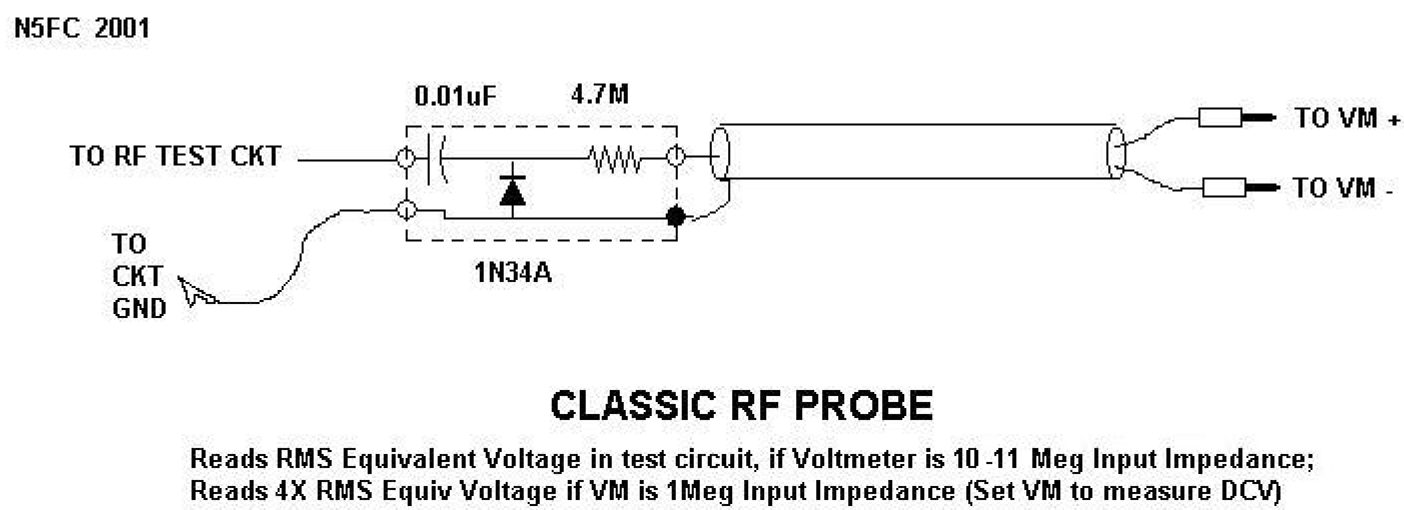
N5ESE's Ballpoint RF Probe



(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

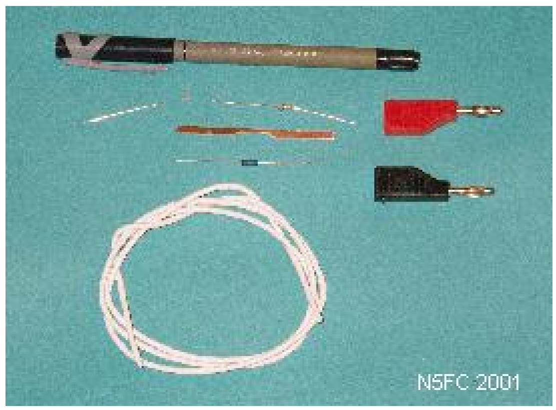
This is one of those afternoon projects that can really be both rewarding to build and useful to have. Electrically, it's identical to the Classic RF Probe described elsewhere (where you can also find the theory discussion for this one). Like the Classic RF Probe, this one is used in conjunction with a high-impedance-input Voltmeter or Digital Voltmeter (DVM). See the schematic below. Cost? About $5, if you can scrounge the ballpoint pen, heat shrink, shielded cable, and copper tape.



What makes this probe unique is that it's built inside the shell of a regular ol' ballpoint pen. Besides being conveniently compact, the unit sports a needle-probe suitable for use in probing surface-mount circuits, and good overall shielding. The pen cap protects the needle probe when not in use. When measuring sinusoidal signals, it should provide RMS-corrected readings, using a 10 or 11-Meg input impedance VTVM or DVM. With a 1-Meg DVM, it reads 25% of the sinusoidal RMS voltage. Reasonable accuracy (+/- 10%) can be expected over the HF/VHF range (2-150 MHz), although this hasn't been verified. When used to measure non-sinusoidal signals, the accuracy will be unknown, but it still affords good relative measurements, and most of the time, that's all that's required. It makes an excellent, compact, and portable accessory for troubleshooting or homebrewing QRP equipment with peak voltages less than 50 Volts (i.e., most solid-state equipment)

Construction

The figure below shows the parts required to build the Ballpoint RF Probe. Click on the image to open an larger, annotated image with parts labled, and construction notes. Pick a ballpoint pen with a non-metalized plastic body, and plenty of room inside. The Papermate Flexgrip model I used had an inside diameter a little over 1/4-inch. We'll use an itty-bitty scrap of double-sided printed-circuit-board to mount the electronic components. Trim the PC board to about 2-12" long and 3/16" wide; don't make it too wide, or it won't fit inside the ballpoint pen. Notch or file a little out of the middle of the pc board, so the 1N34A diode will fit easily inside the pen body. then, on one side only, groove in two places, so as to create 3 lands on the "top" side of the board. In addition to the parts shown, you'll need a 2-1/2" piece of heat-shrinkable tubing to cover the electronic assembly (although electrical tape would do instead), and about a foot of 1/4"-wide adhesive-backed copper tape, commonly available in rolls of 200-300 inches at large hobby stores (like Michaels, and Hobby Lobby). Although a chip capacitor is shown in the photo, a very small disc capacitor will do as well.



Click on the image above to see a larger, annotated image

In the next image (below), we get a close-up of the electronics assembly. You can see the input capacitor straddling the front-to middle lands, and the 4.7 Meg resistor straddling the middle-to-rear lands. The diode, which snuggles into the notch, connects from the middle land to the ground plane on the rear side of the pc board. The diode's banded end goes to the middle land. Break the sewing needle in half, using two needle nose pliers. **WARNING! Use eye and face protection!!** *ALSO NOTE: Don't try to cut a sewing needle with wire-cutters... you'll ruin the cutters.* Avoid straight pins, which dont have the hardness to perform well as probes. Then, solder the sewing needle to the front land, centering it carefully. You might benefit from burnishing the solder-half of the sewing needle with some fine grit sandpaper, to make it take solder a little better. Center it up nicely, as that will make for a professional-looking probe. Solder the shielded cable to the top/bottom of the pc board, center conductor to the rear land on top, and shield to the ground plane on the bottom. Be careful to aviod straggling shield-wires which could short the electronics. Also,solder a 10-12" pigtail of good, flexible insulated wire onto the ground plane, pigtailed rearward. This will be used as the ground wire in our test circuit. Before you shrink the tubing over the electronic assembly, check for shorts between lands and from lands to ground plane, make sure you have the diode polarity correct, and check that the needle is making solid electrical contact, and is mechanically secure.


Click on the image above to see a larger, annotated image

See the next image, below. After the electronic assembly has been heat-shrunk overall, wrap the copper tape all around the electronic assembly. This will be our shield. Near the rear of the electronic assembly, solder the electonic assembly's ground to the copper tape, near or on the cable shield. Alternative shielding methods can be

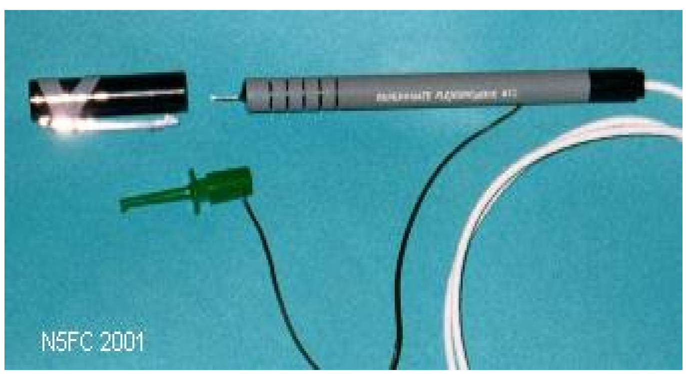
tried, for example, you might pull the shield out of a piece of RG-59, and sleeve it over the electronic assembly, soldering it to the ground plane. Whatever you do, be certain that the shield cannot unravel and short against the probe itself or any of the electronics.

Although not shown in the picture, we drill a small hole about 2/3 back on the pen casing, threading the ground pigtail through the hole. This really tests your hand-to-eye coordination. If the pen has a threaded-in rear-cap, drill a hole in it just big enough to accommodate your main shielded cable. Thread the whole cable into the pen casing, and out the other side, and if you had a threaded rear-cap, like I did, thread it on. Pull the electronic assembly gently back into the casing, so that the needle probe sticks out about 1/2 inch. Mix some clear 5-minute epoxy, and let it thicken ever so slightly. Then , while holding the assembly vertically (i.e., probe-tip up), and using a small toothpick or screwdriver, drop epoxy into the probe area, sealing the electronics and probe into place. Allow to dry thoroughly before applying any pressure to the assembly.

When dry, attach your favorite ground-clip to the pigtail, and banana plugs on the end of the shielded cable (red to the center-conductor, black to the shield, to match your Voltmeter)

Click on the image above to see a larger, annotated image

See the next image, below, which shows the completed assembly, annotated. Sometimes, seeing the entire assembly makes everything perfectly clear. Place the pen cap over the needle probe to protect the assembly when not in use.



Click on the image above to see a larger, annotated image

And speaking of use, here's our lovely model (OK...XYL) making a measurement in the N0SS Noise Generator. She has the ground clip connected to a convenient place in the circuit's ground, and the probe touches the test point we want to measure. As you can see, we read 0.710 Volts. Since this is broadband noise, the actual voltage reading is not accurate, but it was seen to be much greater than the previous stage, as we expected.

Click on the image above to see a larger, more readable image

Let me know if you build one of these... and send me a picture!

73, monty N5ESE

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N5ESE's Classic RF Probe

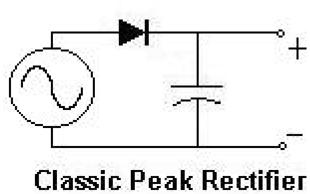
(click on any picture to see larger version)

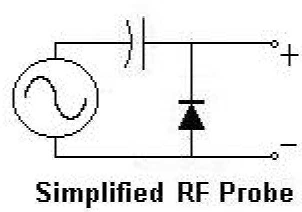
NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

The RF Probe is one of the handiest accessories you can have around the shack. Using only 3 electronic components, it may rank as one of the simplest and cheapest homebrew projects. The one featured here cost about $10 in parts and supplies, not counting the wire, which I scrounged. When used with a high-impedance DC Voltmeter, it can be used to measure RF voltage (and power), trace RF signals in a new design, and troubleshoot malfunctioning RF circuits. It has its limits, of course, and we'll discuss those here. But once you understand how it's used, and how easy it is to build, you'll wonder why you never built one before.

What's an RF probe, and how does it work?

You might think of an RF probe as a special test lead that converts your regular ol' DC voltmeter to a RF reading voltmeter. Why not just read it using your trusty voltmeter, set on AC? Well, because most voltmeters wont read AC signals having a frequency above 10 or 100 KHz, and RF is way above that. [You can buy special RF-reading voltmeters, but they're very expensive... a homebrew RF probe is dirt-cheap]. Let's examine how an RF Probe works.





Above left, we see the schematic of a classic half-wave peak rectifier, commonly seen in power supplies. It's pupose is to take an AC signal at the input (usually from a transformer or the AC line), rectify it, and charge a capacitor. If you don't take a lot of power from the circuit (i.e., if your load doesn't draw a lot of current), the capacitor charges up to the peak voltage of the AC signal, and stays prettty much constant. Notice the simplicity of the circuit: not counting the load, we see it is an AC Source, a diode, and a capacitor in series.

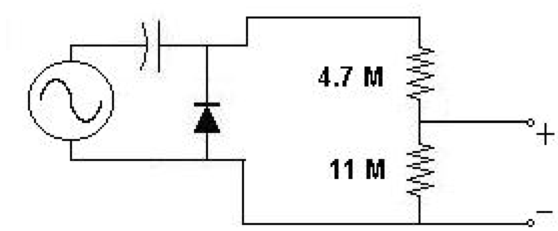
Above right, we see a simplified schematic of the RF Probe. At first glance, it looks quite different from the circuit at the left. But notice: just like the first, it consists of an AC Source, a diode, and a capacitor in series. It's pupose is to take an AC signal at the input (usually from a circuit under test), rectify it, and charge a capacitor.

And just like the first circuit, If you don't take a lot of power from the circuit (i.e., if your load doesn't draw a lot of current), the capacitor charges up to the peak voltage of the AC signal, and stays prettty much constant.

What's the difference between these two circuits, then? One small little thing, really. In the first circuit (the half-wave peak rectifier), any *positive* DC component gets added to the voltage at the output. In the second circuit (the RF Probe), the circuit is insensitive to *positive* DC components. This is good for an RF probe, because we're going to be testing circuits with DC biases applied, and we don't want those biases to affect our readings (we're interested in the AC only, i.e., the RF)

In both these circuits, if we place a DC (not AC) voltmeter at the place where it says "+" and "-" we'll read a DC voltage that is approximately equal to the *peak* of the applied AC voltage. If we knew our applied AC was a sinusoidal signal (or sine wave), then we could divide our reading by 1.414 to obtain the RMS value, which is the way we usually measure AC voltages. Even if it's not a sinusoid, at least we know what the peak voltage is, and that's something we didn't know before we started.

We'll do one more little trick to make the RF Probe more useful, and it will only cost us the addition of a 2-cent resistor. So that we don't have to manually divide our readings by 1.414, we'll use a resistor to create a voltage divider that will do it for us. Here's a classic voltage divider, added to our RF Probe circuit:

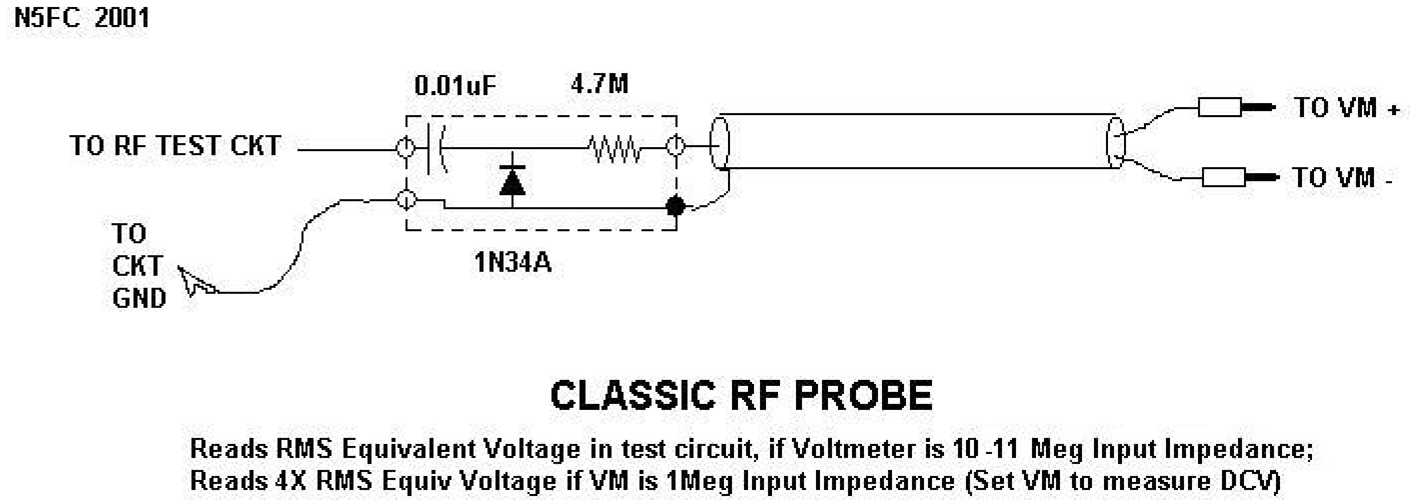


As we know from elemental electronic theory, the voltage across the second resistor (where it says "+" and "-") is equal to the applied voltage multiplied times the ratio of the second resistance divided by the total resistance in series. In our case, for a sinusoidal input, we know the applied DC voltage is equal to the PEAK of the AC voltage. We would like the resistor divider to divide by 1.414, which means that the total resistance in series (including the second resistor) needs to be equal to 1.414 times the second resistance. In our example circuit, shown above, the second resistor is 11 Megohms, and the total series resistance is 11 Megohms PLUS 4.7 megohms, or 15.7 Megohms. Is this ratio 1.414? Pretty close, about 1.427, closer than the typical resistor tolerances.

But wait! I said we would add one resistor, not two! What's up with that? Well, the 11 Megohms is the typical input resistance of a high-impedance voltmeter, like an electronic VTVM or a digital voltmeter. As long as it's 10-11 Megohms, it'll give results close enough for government work (HI). Obviously, it's important to know what your voltmeter's input resistance is, and you can find this out in your voltmeter's specifications, or measure it (I wont get into that). And really, accuracy is often not that important, especially when you're signal-tracing.

Enough! Let's get real... let's build something!

Here's a complete schematic of the classic RF Probe. Simple, eh?



We've added a few things from our theoretical discussion that we'll make short note of. Obviously, for "probing" we need a "probe". (Hey! No wonder I get paid the big bucks...). We add a SHORT lead with an alligator clip. The alligator clip goes to our circuit "ground" and the probe goes to our test circuit, where we're probing. Brilliant! We don't want either of these to be long leads, because we're talking RF here, and long leads = antennas, and we don't want to be picking up stray signals or broadcasting them. 10-12 inches for our ground lead is sufficient for circuits to up to 30 MHz.

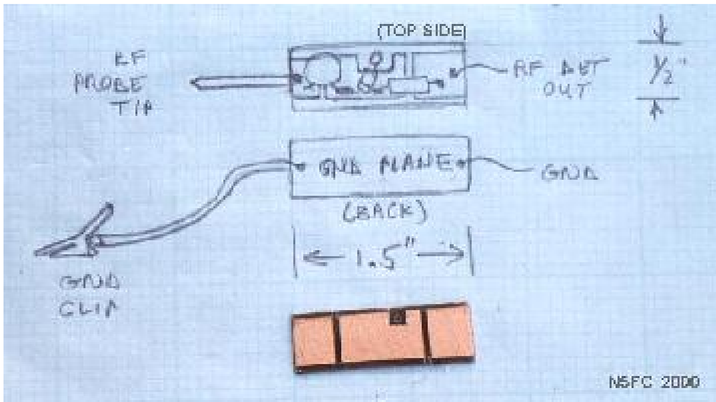
As shown in the schematic, we'll need to shield the RF Probe circuit, or else our hand and body will pick up stray RF and couple it into the circuit, causing erroneous readings. We'll also shield our leads all the way back to the Voltmeter, as shown, for the same reason. At the far end of the shielded wire, we'll mount banana plugs (or whatever will fit our DC Voltmeter).

In case you're tempted, don't make poor substitutions for the diode. We chose the 1N34A because it had the following key characteristics: Reverse Breakdown Voltage greater than 40 Volts, forward voltage (barrier potential) of less than 0.3 Volts, and good RF qualities. Any diode with these qualities (example, the 1N458A) would work as well, but the 1N34A is readily available (at Radio Shack and others). Silicon and Shottky (hot-carrier) diodes, while good RF devices, have higher barrier voltages, and will not work as well at low RF voltages. The 1N34A is a germanium device, and with a barrier voltage of around 0.25 V, provides about the best performance you can get with this simple circuit.

For best accuracy, size the resistor to match your DC Voltmeter's input impedance:

R = 4.7 Meg for Zin = 11-Meg;
R = 4.3 Meg for Zin = 10-Meg;
R = 430 K for Zin = 1-Meg;

Here's one cheap-and-easy approach to building the RF Probe:



Click on the image above to see a larger

Take a small piece of scrap double-sided printed-circuit board, about 1-1/2 x 1/2 inches, Groove it on one side only, similiar to the image above, to create pads for soldering, but leave the back side as a "ground plane". Mount your diode, capacitor, and resistor as shown, soldering to the pads you made. One side of the diode (the non-banded isde) gets connected to the ground plane (drill a hole through to the other side and solder it). Try to fit all the components neatly inside the edges of the pc board. Solder the braid of the shielded wire (3-4 ft long) to the ground plane, and the center conductor to the pad with the resistor. Also, solder a 10-12 inch hook-up wire to the ground plane. Check that there are no shorts between the center conductor and the ground-plane. Solder the probe tip to the pad with the capacitor (I used a discarded probe tip from a broken test probe).

Here's where we get creative: packaging! One way or another, whatever method we use, it's important to shield the probe circuit, yet without shorting any part of the circuit to our shield (except the ground plane). I was on a kick of using copper pipe, which is very cheap, so I built my shield out of 1/2-inch copper pipe and end caps, commonly available at your local hardware store. I drilled a hole in the end of each end-cap, to pass the shielded cable and the probe tip. I used a shouldered washer to insulate the probe tip from the end cap, but a small rubber grommet would have worked as well. Stuff the assembly inside the copper pipe, and you end up with a completed probe that looks like the following:

Click on the image above to see a larger version

So, how do we use this thing?

Before we use it, a few precautions are in order. Don't use the probe in any circuit where the highest DC supply voltage is greater than the diode's reverse-breakdown voltage. For the 1N34A, this is 50 Volts. Same goes for the capacitor, which should be rated at least 50 Volts. This probably means that the probe cannot be used in most tube circuits. Also, don't try to measure RF power in circuits where the peak voltage will exceed 50 Volts. What will happen if you exceed these voltages by a little? Well, probably nothing; possibly, the diode or capacitor will fail open or short.

The first thing you'll always do in using the RF Probe is to connect the banana-plug end to the +/- jacks of your DC Voltmeter; set the Voltmeter to DC-Volts (not AC).

To use the RF Probe for signal tracing in a malfunctioning RF circuit or a homebrew circuit, connect the aligator clip to a convenient "ground" or "common" point in your circuit. Often this is the chassis. Most of the time, you'll be probing at the base/gate, emitter/source, or collector/drain of a transistor, one either side of a coupling capacitor or transformer, or at the input or output of an IC. Because the circuit's RF must overcome the diode's barrier potential (of 0.25V, for our 1N34A), voltages much less than that won't read at all, and voltages less than about a volt won't read very accurately. Typically, RF and post-mixer-amps in receivers don't have enough RF voltage, unless you inject a very strong signal at the input.

I recently used my RF probe to troubleshoot my dead TenTec Scout, which had suddenly quit transmitting in mid-QSO. I connected the rig to a dummy load, then keyed it while probing. Using the probe, I was able to follow a steadily increasing RF signal through the transmit chain, from the oscillator through the transmit mixer, to the pre-driver, and the driver. The actual voltage measurements weren't important, just that they were increasing from stage to stage where expected. Then, (whoops!) the driver's base circuit had 6 Volts, but the collector circuit only had only 0.1 Volts! The driver transistors had gone south!

You can also use the RF probe to measure RF power with reasonable accuracy, up to about 50 watts in a 50-ohm circuit. By 50-ohm circuit, I mean a 50-ohm antenna system at 1:1 SWR (higher SWRs are not 50 ohms), or a 50-ohm dummy load. Assuming the resistor in your RF probe is sized to match your DC Voltmeter's input impedance (as explained above), you will get quite reasonably accurate measurements using the following formula:

$$PWR = \frac{(V_{(read)} + 0.25)^2}{R_{(load)}}$$

For example, I want to measure the power out of my TenTec 1340 40-Meter QRP transceiver. I place it on a 50-ohm dummy load, and key down. I generally use a BNC-Tee adapter to gain access to the output line, but I could as easily pop the cover off. Using the RF probe (alligator clip to chassis ground), I measure12.2 Volts (DC) (and the same RF RMS Volts). Plugging this into the formula above I have PWR= (12.2 + 0.25) * (12.2 + 0.25) / 50 = 3.1 Watts. The rated power for this rig is 3 Watts, so I've verified everything is hunky-dorey.

We've added the potential barrier to the measured voltage above, but that little trick doesn't work so well when you get down around a volt, and for voltages less than about a volt, the measurement accuracy suffers greatly. Also, the diode's response is severely non-linear below the barrier potential, and will generally read much less than expected in circuits where the RF voltage is less than 1/4 volt. So if you see tiny readings in circuits where it's normal to have voltages less than 1/4 volt RF, don't get too spun-up about the low readings... it may mean everything is normal. My rule of thumb for guessing at this is as follows: For collector/drain circuits in oscillators or transmit-chain amplifiers in key-down, expect RF Voltages about 20-50% of the applied DC (supply) voltage. This depends on the circuitry, of course, but it's a reasonable gesstimate. Base/gate and emitter/source circuits will generally be much less, maybe 5-10%. Circuit impedance will affect this too.

How good is this thing?

Well, we're not talking high performance test equipment here, but we *are* talking very useful. If you account for the barrier voltage, the readings can be quite accurate when measuring most low-impedance circuits (20-200 ohms), provided that the voltage is above 1 or 2 volts. How accurate? +/-10% from 200 KHz to 150 MHz would be a reasonable expectation. Also, the voltage divider is only accurate for sinusoidal signals. If you want "peak" measurements, simply multiply your reading by 1.414. The "peak" measurement should be good regardless of

whether the waveform is sinusoidal. Regarding ultimate accuracy, your results may vary, and you may want to compare it to a laboratory instrument at the frequency of interest if you're really interested in accuracy. If you shield it well, and keep the ground clip lead reasonably short, it should be good in low-impedance circuits up into the VHF region, and down into the upper-audio region. In higher-impedance circuits, the junction capacitance of the diode may cause a low-pass effect at higher frequencies, and you're most likely to see this as a loss of measurement accuracy (i.e., low readings) at frequencies above 30 MHz. This doesn't mean it's not useful; it just means it reads low. Also, the capacitance of the probe may affect some sensitive RF circuits. For example, if you're probing a LC-tuned oscillator circuit, it may stop oscillating or change frequency or become unstable. Actually, most any probe will do this. Also, as we said before, the barrier voltage becomes a bigger part of the measurement error as the circuit voltage drops below a volt or so, and becomes dominant as you approach the barrier voltage. Just keep this in mind as one of it's limits.

Enjoy, good luck, and 73!
monty N5ESE

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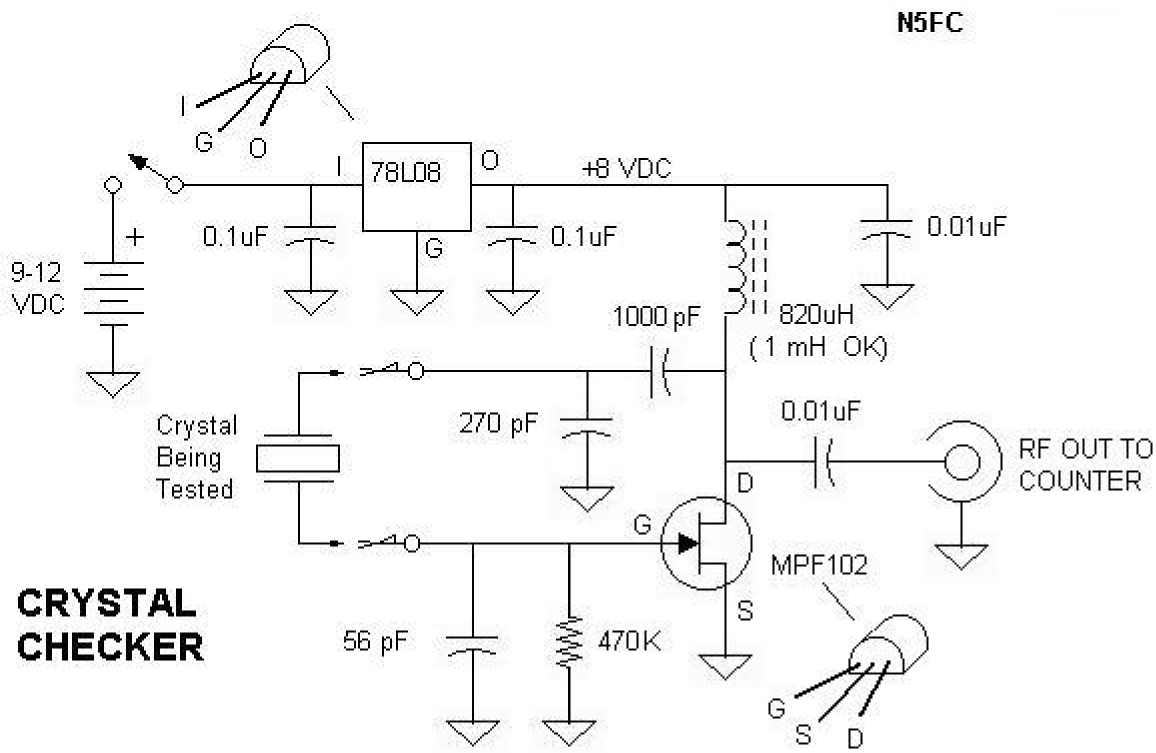
N5ESE's Crystal Checker

(click on any picture to see larger version)

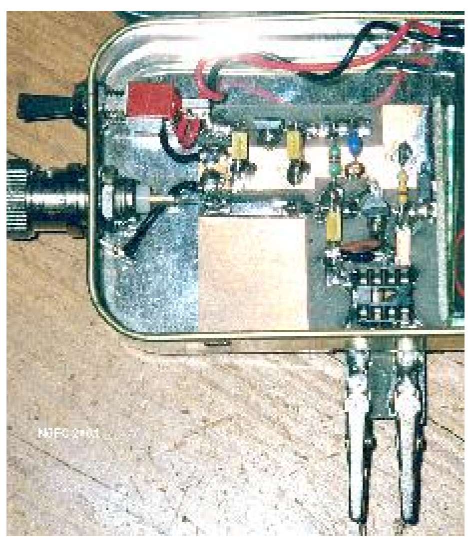
NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

The N5ESE Crystal Checker is a weekend project based on a simple oscillator circuit designed to work readily with most any fundamental-mode crystal in the HF range. Used in conjunction with a frequency counter, it allows you to test the viability of unknown crystals, or match a bunch of crystals for use in filters.

The circuit is quite straightforward. It was adapted from a similar circuit by W1FB, presented in QST Jan 1990. The schematic, as built, appears below:



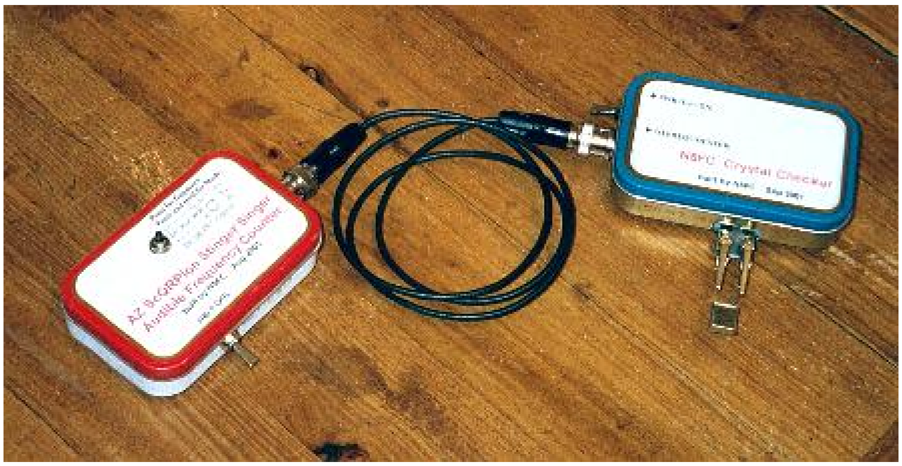
I love putting things in Altoids boxes (could you tell?). This project was the perfect size for it. We built a small printed circuit board (PCB), cutting islands and traces using a hobby knife (CAUTION! Wear Safety Glasses!). The PCB is shown below:



As you can see, the PCB extends through a hole in the Altoids box, where two alligator clips (RS 270-380) are solder-mounted. We can clip our crystal here, for testing. An 8-pin DIP socket is also included, surface-mounted to the top of the board, and we can mount a crystal here instead, if we like.

The Altoids box has plenty of room for a 9-Volt battery, making the unit self-contained and readily portable.

In use, we connect a frequency counter to the Crystal Checker's output, via a BNC cable, and connect a crystal for testing. See below, where we have connected it to the AzQRPions Stinger Singer Audible Frequency Counter (packaged N5ESE-style, in an Altoids box, of course...)



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N5ESE's Dual-Band Version of the AmQRP Softrock Receiver (20051119)

A "Software-Defined Radio" (SDR) Receiver

(click on any picture to see larger version)

I am always amazed at the creativity and downright ingenuity of hams. QRP homebrewers seem to be the cream of the crop in this regard. Witness the AmQRP Club's line of kits, which are nothing short of state-of-the-art electronics at dirt-cheap prices. Wow!

Now, in conjunction with the NJQRP Club, they recently released the "Softrock-40", a minimalist hardware implementation of a full featured 40 Meter receiver. Sounds like a contradiction in terms, but the philosophy is simple, and it works! Namely, keep the hardware as simple as you can, and feed the audio to the soundcard in your PC, so that the PC can do the real work of tuning, detection, demodulation, filtering, agc, and producing a sound fitting for your ears. With such an approach, features undreamed of in a cheap receiver are possible - features like panoramic spectrum displays, tuning with your mouse, and DSP filtering. It's nothing short of amazing, especially when you consider this is done with:

- A printed circuit board about 1 x 3 inches;
- $23 for the entire kit of parts;
- A run-of-the-mill PC with built-in soundcard
- freeware software

The AmQRP Club sold 800 of these kits in two runs, over a period of less than 2 months. That's how much interest there is in this kind of radio. Currently, this particular kit is retired, but the designers are working on the next hardware version. Software is continuously being modified and features being added by various accomplished programmers throughout the QRP community. It really is exciting!

The hardware schema is based on the Tayloe Quadrature Detector, which serves as both the front end and a direct-to-baseband converter. It is driven by a crystal oscillator operating at 4-times the receiver center frequency. It provides a 2-channel I/Q audio output in quadrature channels (that is, 90-degrees shifted). Given I/Q audio, a sound card with stereo inputs, the right software can provide single-signal reception. Depending on your soundcard and it's sampling rate capability, band coverage will be somewhere around +/-12 KHz to +/-24 KHz of the band. The AmQRP kit was designed for 40 Meters, and was designated the SR-40, or "Softrock 40". If you'd like to see a schematic, and pictures of the stock board assembly, go to the AmQRP Softrock webpage. See how simple a radio can really be.

You know I had to get one, and you know I had to modify it ;-)

My Approach (Mods), and Construction Details

The hardware is assembled onto a small pc board. It uses surface-mount IC's, which mount on the bottom side of the board. These are 50-mil pitch, which is easily soldered by anyone with a modicum of soldering experience. We suggest, for success, three things: 1. a pair of head-mounted magnifiersl; 2. a fine-tipped soldering iron (no larger than 1/16-inch tip); 3. simple patience. OK, about half of you dropped out on point No. 3 `;-)`

The stock kit is probably just fine, but try as I might, I just couldn't leave it alone. First, it *had* to go in an Altoids tin. [I know, it's a sickness...]. Secondly, I wanted more than one band, but I wanted it very simply. Actually, I didn't think of that, someone else did, but I jumped on it immediately when I heard the proper crystal was available for a song-and-a-dance. Thirdly, I wanted it to operate from a 9-Volt battery.

The device was intended to operate from the USB port of the PC, plugging into it directly. QRPers quickly figured out that better performance and less noise was possible if you powered it externally, and a 9-Volt battery seemed like a logical choice. But for this, a linear regulator was required, to knock the voltage back down to 5 Volts. I used a 78L05 regulator (in the TO92 package, and a couple of 0.1 uF capacitors for decoupling.

The first thing I had to do (I thought), was chop about 1/8 inch off the USB Connector end of the board. Without the USB connector, the SR-40 pc board fit in the Altoid tin width-wise. Then, because the power circuitry was on that end of the board, I mounted the regulator components there, ugly-construction-style. One of my fellow AQRP'ers showed me his version in an Altoids tin, with a 9-Volt Battery also, and he didn't have to cut down the board. I'm not sure the extra switch for band-switching would have fit in (but it might have).

Because I intended to use a small toggle switch to switch between crystals for 40 Meters and 30 Meters, I needed to find some space to mount a second crystal. The crystal for the 40M version was the small version HC49US, while the crystal for 30M (40.500 MHz) was the full-sized HC49 package. We mounted the larger crystal using double-sided 3M foam taoe, in an area of the board which had just enough real estate, close by the original crystal's location. We left one lead (on each crystal) sticking up in the air, to attach via hookup wire to our band switch.

Here's what those regulator and band-switching mods look like:

(click on any picture to see larger version)

And here's what the overall packaging looks like, with the cover open and the 9-Volt battery installed:

(click on any picture to see larger version)

Software

There are at least two dominant software packages out there. One, recommended by AmQRP, is a version of the same software used in FlexRadiio's big brother full-featured commercial Software-Defined Transceiver, the SDR-1000. That software package, called PowerSDR 1.4, is available at the Flex Radio web site. Before you install that software, you will need the Microsoft "NET Framework" installed on your computer (available free from Microsoft). For the XP operating system, you'll also need to be running SP1 (the latest service pack from Microsoft). Some people may also need some soundcard interface software, but most (as I understand it) do not if they have a fairly recent PC running XP.

Here are my instructions for installing the software, FWIW:

```
--------------------------------------------
Installing SDR-40 software for an XP machine
--------------------------------------------

1.  Make sure Microsoft NET FRAMEWORK is installed on your PC:

        a.  Install NET FRAMEWORK (run 'dotnetfx.exe')
        b.  Install SP1 (security patch; run 'NDP1.1sp1-KB867460-X86.exe')
        c.  You will be asked to restart the computer

2.  Install the Universal ASIO software:

        a. run 'A4Av2Ins.exe'

3.  Install the PowerSDR Software:

        a.  unzip 'PowerSDR_v1.4.4.zip'into a temprary folder
        b.  from the PowerSDR\Install folder, run 'setup.exe'
        c.  Observe and note the folder where installed
            [by default, "C:\Program Files\FlexRadio Systems\PowerSDR v1.4.4\"]

4.  Install the SDR Overlay:

        a.  Unzip 'PowerSDR-1.4.4-SR40-Binary-20050827.zip'
            into the folder where PowerSDR was installed
        b.  run 'PowerSDR.exe'

5.  On initial startup, PowerSDR software will enter the Configuration wizard.
        a.  Answer all the configuration questions "NO",
        b.  Enter "unsupported soundcard" if your soundcard is not one
            of the cards on the list
```

```
6.  test the software using I/Q WAVE files:

        a.  48k_cw10108.wav
        b.  IK3MAC_CQ_high_noise_12-5-2004_12_46_44_AM.wav
        c.  From the menu bar in PowerSDR, choose WAVE,
            then ADD these files to the playlist
        d.  to hear them, click the "STANDBY" button to "ON"
```

Please don't ask me for advice on installing software... I know how I did it (see above), and beyond that, I'm totally ignorant.

One alternate software package, which is receiving rave reviews from users, is offered by VE3NEA, and is available at his web site.

Conclusions

I've tried both software packages on my Dell 2400-Series (El Cheapo) XP machine with integrated soundcard, using the wavefiles (noted above) for testing, and found both software packages to be really cool. I really can't decide which I like better, but I'm leaning toward Rocky right now.

As for the hardware performance, I really can't draw any conclusions yet. I haven't had time to put power on mine and play with it. But feedback from many, many builders indicates it's a really cool little receiver. It is said to have a noise floor of -128 dBm which is very hot. If it works at all - hey, at $23 - how could it be anything less than spectacular?

There is a *very* active mailing list for this group. Go to Yahoo Groups and search for the group called "softrock40". If you have any questions, or want to delve more deeply into this project (and its follow-ons), this is the place to go 73, and enjoy!
monty N5ESE

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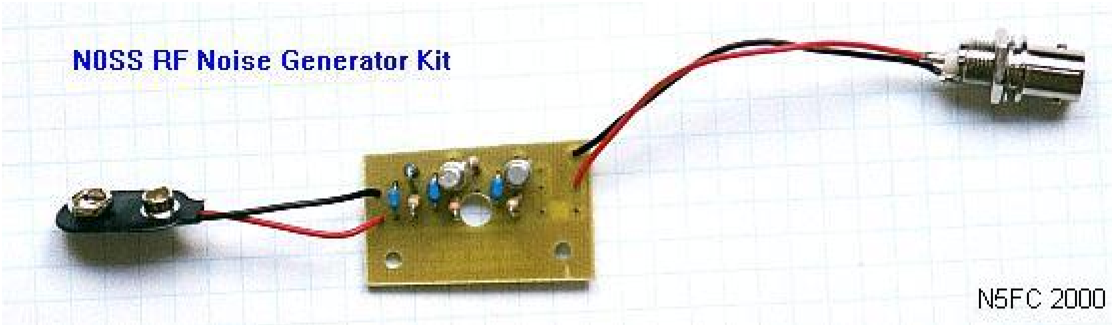
N5ESE's Experiments with Broadband Noise Generators



(click on any picture below to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

I'm always on the lookout for useful gadgets that make it simple to do a big job. Well describe a few such products on this page. We'll look at how a very simple RF noise generator can be used to measure receiver filter response, for off-the-air antenna tuning, for making antenna measurements, and for troubleshooting electronic circuitry.

Measuring Filter Response

Broadband noise generators have been around for a long time. If you're not familiar with them, you're going to be amazed at how simple they are to build, and how useful they can be around the shack, especially when used in conjunction with some recently available (but very sophisicated) software for PCs.

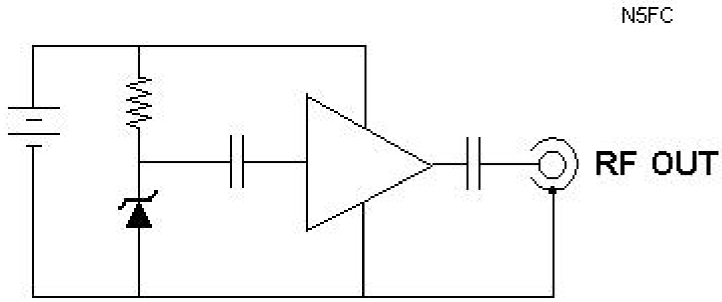
The noise generator is used to synthesize an RF signal which has noise components uniformly distributed over a very wide bandwidth. If the level is high enough above the self-noise of the receiver being tested, it provides a basis for some very practical measurements. If you were to look at that signal before it got to the receiver, with an RF Spectrum Analyzer (in the frequency domain, that is, amplitude vs. frequency), you would see a flat line indicating the amplitude of the noise, and it would span a large bandwidth (generally, much larger than the radio receiver's bandwidth). Alas, RF Spectrum Analyzers are relatively expensive, especially those capable of accurate measurements at receiver bandwidths. Rats!

If you were to feed such a noise signal into your receiver, and listen to it, you would hear a very loud hiss, and no matter where you tuned across the band, you would hear the same hiss sound. So what? What useful purpose can that have?

Well, if you can say definitively that there is a uniformly distributed RF noise signal coming into your receiver, and if you had the equipment to look at the frequency spectrum of the detected signal (coming from the audio output), you could measure the aggregate response of all the filters in your receiver. Hey! That's useful stuff, especially if your homebrewing receiver equipment.

Is it really that easy?

Here's the classic RF Noise generator circuit (solid-state version):



CLASSIC RF NOISE GENERATOR CIRCUIT

If you look at the first three components on the left, you'll recognize another classic circuit, that of the zener regulator. In that applicatioon, you allow a DC current to pass through a reverse-biased zener diode. The zener diode then regulates that current to a fixed DC voltage, as determined by the diode's reverse-avalanche characteristics (or "zener" voltage). All well and good. But look a little more closely, and you'll see something's missing - the output filter capacitor. While that's a very important part of a DC power supply, it's our worst enemy if we're building a noise generator. Somebody a long time ago decided to save a few pennies and leave out the filter capacitor, only to discover that the zener was generating a bit of broadband noise, all on it's own. *But hey!* That's what we're after. If we now pass that through a coupling capacitor (to block the DC component, which isn't useful to us), and feed it to a suitable high gain amplifier, we end up with useable noise at the output. And it turns out that the noise is quite uniformly distributed, with components from audio frequencies well into the VHF spectrum. Excellent! (By the way, the coupling capacitor is sized to allow RF to pass, but not DC or audio, but if you wanted an audio noise generator, you'd just size the coupling capacitor larger.)

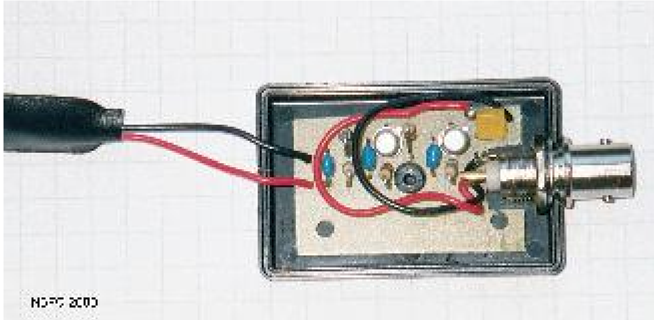
The ampliffier can be any high-voltage-gain (40-60 dB, or x100 - x1000), broadband amplifier, with a low enough output impedance to drive the intended load. For our applications in ham radio, this usually means we're driving the receiver front end (50 ohms, typical). Is such an amplifier complicated? Not at all, as it turns out. Two or three 2N2222 transistors (at 5 cents apiece) and a few resistors are all that's required to build a suitable amplifier.

The N0SS RF Noise Generator

As if that weren't easy enough, along comes Tom Hammond (N0SS) and the Arizona ScQRPions. They provide a parts kit [alas, no longer available], including printed circuit board, to build just such a noise generator. All for $10. Yes, $10... CooOool! You provide a 9V battery (or other DC power source) and a way to get the signal to your receiver, and you're in the RF noise business! The original application for this kit was to provide kit builders a means of tuning the main bandpass filter characteristics on the Elecraft K2 transceiver kit. But (lucky for us), it works just as well for any amateur receiver!

Show-and-Tell

Here are some pictures of my version of the N0SS Noise Generator kit. I decided to package mine in a teensy project box made for key-chain remote controls (Radio Shack p/n 270-288 $1.99). I gouged a hole in one end of it (using a hobby knife) to mount the BNC-jack (UG-1094 or RS 278-105 $1.99). And I powered it from a 9 Volt battery, using the battery clip (RS 270-325 $1.39) to turn it on and off. (Click on any picture below to see larger version)



[View, cover removed]

I drilled a hole exactly in the center of the printed circuit board, just big enough to slide over the plastic standoff inside the key-chain box. In doing so, I think I cut one trace, which I re-routed using a piece of wire-wrap wire. I also used a nibbler on the output end of the board, to accommodate the NBNC jack's tail end, and tack-soldered the wires to the output traces on the PC board. When done, I screwed the cover on (one screw), and it ended up looking like this:

[View, cover installed]

Snazzy, heh?

Alternative Packaging (or, What About My Altoids Compulsion?)

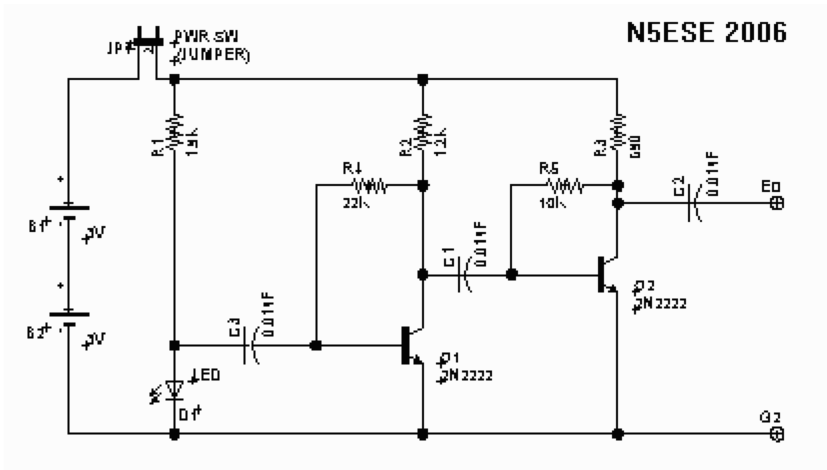
The packaging above was quite nice, but I wasn't happy until I could enclose both the battery and noise circuitry - and what better way to accomplish that, than in an Altoids tin? We'll show two different Altoids packaging schemes, beginning with the traditional (the N0SS noise gen), shown below, which needs no particular explanation:

[repackaged in Altoids tin]

Super Teensey Weensey Altoids Packaging

This may be the worlds smallest noise generator project - I'll make that outrageous claim, and hope someone will surpass it, which I'd really like to see ;-)

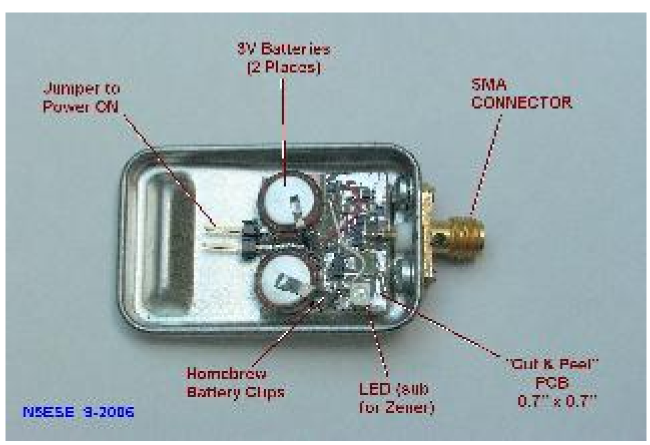
Have you ever been standing by the cashier's counter at the drug store, waiting in line, and noticed a teeney-weeney Altoids box, for holding breath-mint strips, about an inch wide and less than a quarter-inch thick? Well, a friend of mine did, bought it, and challenged me to build something in it. I didn't want to do something as simplistic as an LED flashlight (which is still a good project); I wanted to do something truly electronic, and have it completely self-contained (which meant, batteries included). A noise generator seemed like a good candidate. I went with the following schematic:



N5ESE Teensey Noise Generator Schematic
Click on image for larger version

Note that in place of a zener diode for noise generation, we substituted an LED. We still got plenty of broadband noise, but even with the same supply voltage, the output level was about 6 dB lower than with the N0SS circuit.

To pull off this packaging challenge, we needed two things: surface mount components, and very small batteries. For the batteries, we selected the Panasonic ML612S rechargeable 3-Volt MnLi coin cell. At about 1/4-inch diameter and 1/20th inch thick, we could easily fit two inside. I wanted a battery holder and Keystone makes one (their p/n 2991), but the minimum order was too much, so I kludged together some homebrew battery holders using tiny strips of steel cut from an Altoids tin (what else?). It didn't work too well, and I wouldn't recommend it, but it worked HI HI. See below:

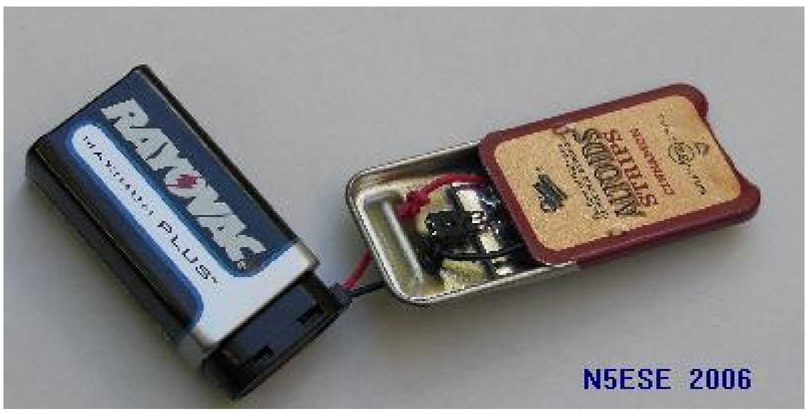


The pc board was built as I frequently build one-off surface mount boards: using the tried-and-true "cut-and-peel" technique, i.e., utilizing a hobby knife to remove unwanted copper and form islands.

Caution! When using a hobby knife, always, always, ***always*** wear safety goggles!

Yes, the completed assembly really did fit comfortably inside the teenset-weensey Altoids tin (total volume less than 1/4 cubic inch, and it really did work! Here's a picture, for scale:

The homebrew battery clips proved not to be reliable, and I guess I wasn't too surprised. So rather than risk an accidental short against the case, or intermittent operation, I finally reverted to an external 9-volt battery, as shown below:



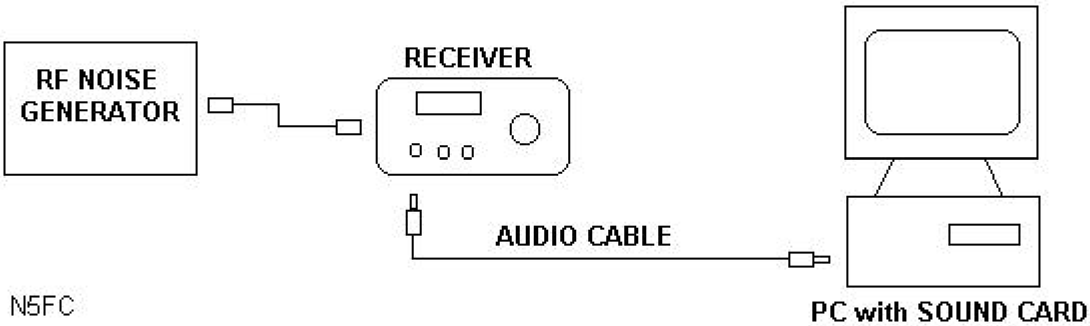
All well, but now what do we do?

Well, we've managed to get the RF noise to the receiver, but now what? Did I mention Easy Street? There are a number of FFT software programs available, which use the PC's soundcard to sample the audio from your receiver, and provide a visual presentation of the spectral (frequency) content of that audio. For years, Richard Horne's Spectrogram software was provided free-of-charge, but now I see that it has a 10-day timeout, after which you must register for $50 (ouch!). While I haven't tried alternative programs, there are a couple that are still freeware: DL4YHF's Spectrum Lab, and I2PHD/IK2CZL's Spectran. Also, Spectrogram V5 may still be available -here- or -here- or -here-, but may not work with Windows XP.

When used with a broadband noise source (like ours, or the N0SS generator), these FFT software programs allow us to visually observe and measure the the frequency response of the aggregate circuitry (i.e., our receiver).

Spell it out for me...

Here's how it's done:



NOTE: The following procedure was written for the Spectrogram V5 software (running under Windows 95); if you're using something a little more up-to-date, you'll need to adapt, but the general procedure will be similar, if not the same.

1. Provide a cable from your RF Noise generator to your receiver's (or transceiver's) antenna jack
2. *Don't transmit*

   CAUTION! To avoid possible damage to yourself or your equipment, power the receiver and the PC off the same AC outlet. At the very least, measure the AC voltage between your receiver chassis and the PC's chassis (touch bare metal). It **must** be less than 1/2 volt or so, the smaller the better.

3. Provide a cable from your receiver's audio output (usually, the headphone jack), to your PC soundcard's LINE or MIC input. Usually, the LINE input is preferrable, but if that doesn't provide enough level, use the MIC input. Usually, you need a cable with a 1/8" stereo plug to connect to the soundcard input. It doesn't matter which channel you use, the Spectrogram software will find it.
4. Check that you can hear your receiver audio in the PC's speakers. To do this, you'll have to open your soundcard software, and play with the audio (or playback) level controls. [Don't ask me how to do this on your computer; I won't know]. On my MS Windows 95 machine, I click **Start | Settings | Multimedia | Audio**, then adjust the slider control "Playback". If you can hear the audio, you've made all the correct connections, and done everything right up to this point.
5. Spectrogram.
6. After you've started the software, select **File | Scan Input**. The software will present a dialog box with lotsa choices... click the **"Line"** switch in the "Display Characteristics" box, then click **"OK"**... leave the other choices at their defaults. (if the **Scan Input** dialog box is not presented, click the **"STOP"** button and try again.
7. Your receiver's spectrum should appear in graphical form. Click the **"STOP"** button to suspend analyses, and you can then print it out if you want. Or, save it to an image file using **File | Save Image**... RAD!

OK... Real Measurements

Here are some measurements I took from my own receivers. I was really curious about the response of my TenTec 555 Scout, which has a continuously variable XTAL filter (called a Jones filter, after the inventor and patent-holder). I wanted to know exactly what the filter response was at each position of the pot, in "clock" settings (all the way left being 7-o'clock, straight up being 12-o'clock, all the way right being 5-o'clock). I was also very curious about my IN3 DC-RX receiver (in the mini-Altoids box), which had a 2-position audio filter in it. Finally, I wanted to see the response on my TenTec 1340 QRP Kit, which has the cleanest filter I have ever heard in a cheap kit transceiver. Here we go:

Note: Each image is about 70 KB
TenTec Scout, Filter response with control at 7-o'clock (all the way left)
TenTec Scout, Filter response with control at 8 && 9-o'clock
TenTec Scout, Filter response with control at 10 && 11-o'clock
TenTec Scout, Filter response with control at 12 && 1-o'clock
TenTec Scout, Filter response with control at 2 && 3-o'clock

TenTec Scout, Filter response with control at 4 && 5-o'clock (all the way right)
N5ESE's IN3 DC-RX, CW/SSB Filter response
TenTec 1340 QRP Transeiver kit, Filter response

I learned a lot about my equipment. My TenTec Scout's low-frequency attenuation isn't very good. I sorta knew that, but I wasn't sure. I think my filter needs tweaking. Also, I could plainly see a "spur" at 1250 Hz intervals, which explains the little "whine" I hear when I have headphones on it. I'm not sure what's causing that. The Jones Filter, in general, works great, as you can see from the graphs.

On my IN3 DC-RX receiver, I learned that the SSB filter falls off a little too quickly, and is a tad narrow for SSB. I kinda like it that way, because I'm a CW op. But the narrow filter is "just-about-textbook" the way I designed it.

With the TenTec 1340 QRP Kit, it was easy to see what makes it such a good CW transceiver. The XTAL filter response is as clean as one could ever want.

...More Stuff Comin'...

We'll add narratives here, on using the RF noise generator to do off-the-air antenna tuning, making antenna measurements using a simple bridge circuit, and troubleshooting receiver circuitry . That will have to wait until I get a little more time and ambition (wink). In the meantime, check the TenTec Amateur Products "TKIT" site for the TKIT-1051 Transmatch Tuning Bridge, which is an excellent (and *cheap!*) example of using an RF noise generator for antenna tuning. My version of the TKIT-1051 can be seen -here-, packaged in -- what else? -- an Altoids tin.

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maddog homepage Visit our regular (non-ham, but very popular) homepage

N5ESE's Free-Standing Antenna Frame

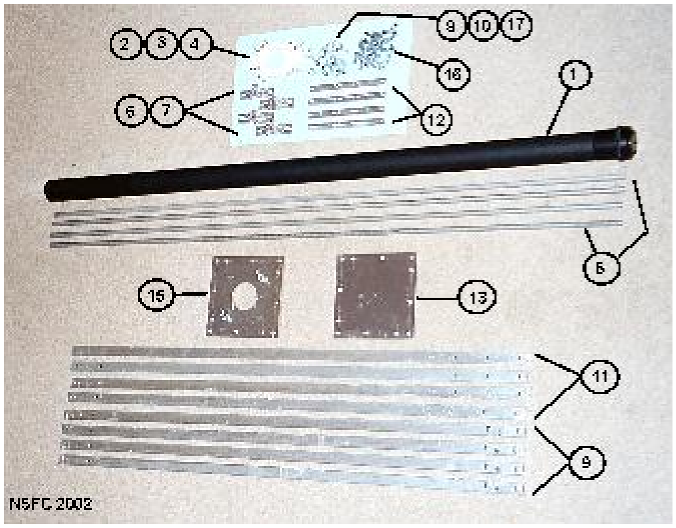
(click on any picture to see larger version)

Look Ma, no guys!

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

Trees in the hill country west of Austin tend to be "puny", growing to only 20 or 25 feet, so I recently purchased a 32 foot DK9SQ telescoping fiberglas mast (available from Kanga US) to get the antenna above the treetops (or bush-tops, as the case may be). One of the things I noticed in central Texas, as I tool around the countryside looking for a neat spot to operate QRP portable, is that finding a tie-off point for a portable mast (or sometimes, just finding a crack in the rocky soil to pound in a tent stake) is sometimes a challenge.

This page presents the construction details for a free-standing antenna frame, designed to support the DK9SQ mast (or the MFJ Enterprises mast, of similar construction). The total weight of the frame is 8-1/2 pounds, a good match for the 4-1/2 pounds of the mast. The frame is compact, and breaks down almost entirely into pieces 3 feet or less in length, making it quite compact for traveling and carrying. Here's a picture of all the parts, spread on the floor prior to packing:



(click on the picture to see larger version)

No, I didn't paint those numbers on the floor with magic-marker - boy, would I be in the doghouse for a long time - we'll use the index numbers later.

I pack mine into the canvas bag that came with my 6-1/2 pound, $20 aluminum/canvas folding chair, and keep it in the trunk of my car, along with the mast and QRP field kit. The picture at the top of this page depicts the mast setup at the destination of a four-mile hike to operate in the "Flight of the Bumblebees" contest, during which I carried a small backpack with the K1 and accessories, the chair and frame in the canvas bag, and the DK9SQ mast in it's cloth bag. Setup takes 15-20 minutes, and the mast was seen to be unconditionally stable with wind gusts of 20-25 mph (higher winds have not been encountered).

Construction

The frame is mainly made of aluminum stock. When assembled, it forms a steady base, into which the bottom of the mast may be securely locked in place. Four horizontal legs arranged at right angles, attached to a small, central base plate form mechanical ground-contact for the frame. Each leg is about 6 feet long, making the base footprint a substantial 11-1/2 feet diagonally. Four lightweight struts quickly and easily attach near the center of the four horizontal legs, then join to a custom clamp about 3 feet up from the base of the mast. The clamp is a two-piece semicircular affair made from strong, thick ABS plastic, which gently but firmly grips the mast without crushing it. Once deployed, the frame is extremely stable, but light enough to pick-up and re-position with one hand. Forces (usually caused by wind) applied to the exposed mast, tend to be transmitted downward into the struts, then through the struts to the middle-point of the extended legs. During field deployment, we observed the tip of the mast swaying 2-3 feet during wind gusts, yet the bottom of the mast and its frame never budged even a fraction of an inch.

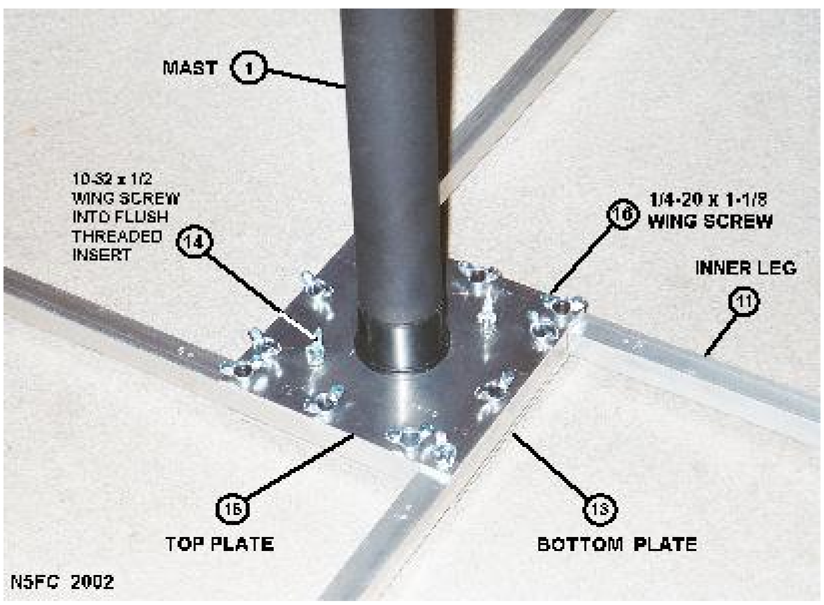
Sometimes a picture is worth more than a thousand words, and such is certainly the case with this contraption. So let's tell the story in pictures. Later, we'll present dimensioned drawings of the piece parts, and pictures from the field.

Here's a picture of our first assembly, accomplished in the family room (with the YF chuckling softly in the background).

(click on the picture to see larger version)

Only half the horizontal legs can be seen (i.e., the inner legs)... there simply wasn't room to assemble the outer legs. One outer leg (the one "comin' at ya") is installed, but you can only see a few inches of it, though it extends another 3 feet toward you. Notice the four aluminum tubing struts, and where they connect to the horizontal legs about 3 feet from the base plate, and where they connect to the special clamp, about 3 feet up the mast. We'll look at more details of these soon.

Here's a closer look at the base and base-plate assembly:



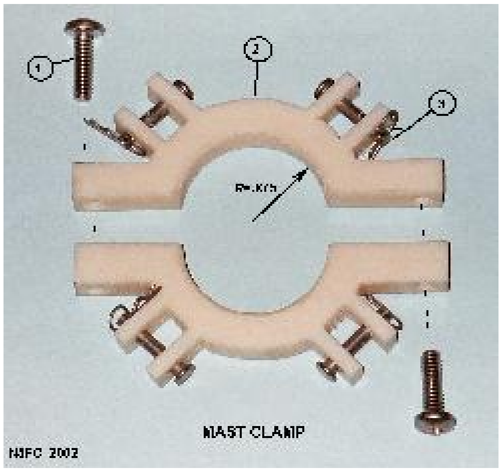
(click on the picture to see larger version)

Several key details will be noted in the above picture. The horizontal legs are captured and held in place between two 6x6 inch heavy aluminum plates, sandwich-style. All assembly is done using wing-headed screws, to minimize the need for hand tools. In the center of the top baseplate, we cut a 2" diameter hole (but not in the bottom baseplate). The DK9SQ mast has a screw-on cap at the bottom; unscrewing it reveals a length of threaded mast, which fits cleanly into our 2-inch hole. Screwing the cap back on captures the mast to the top plate. [By the way - *I can hear the gears turning* - the mast threads themselves are nowhere nearly strong enough to support the mast, so don't even think about it.] Each horizontal leg gets three screws going all the way

through. I mounted threaded-inserts in the bottom plate to receive the screws... that way I don't have to carry (and lose) nuts. I stamped each metal piece with an index letter, so that I could easily remember the assembly order. You'll also see two additional wing-screws, mounted to the top plate. These are placed to afford electrical ground points, should you want to use them. The frame comprises four six-foot radials, and you can use the ground points to attach additional radials and your coax feedline's shield, if desired.

By the way, you may be wondering about the circled numbers. These will index to the overall assembly drawing, and the parts list, to be presented later. You'll see these in a lot of the drawings and pictures.

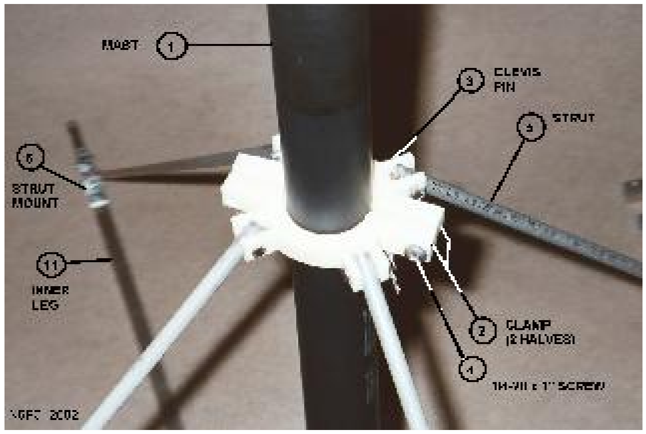
Let's look at the mast-clamp assembly next:



(click on the picture to see larger version)

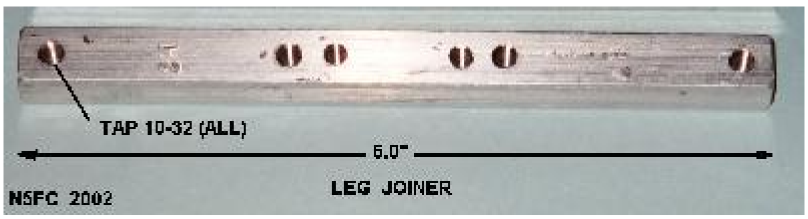
The clamp assembly is made up of two identical halves. It looks complicated, doesn't it? This piece would cost a fortune to have commercially fabricated in a machine shop, but we're not nearly so picky... plus, we don't have a fortune. I selected ABS plastic for the material. It's extremely strong, and drills, taps, and machines well. I printed the drawing of the half-clamp to X1 scale, then scribed the shape onto the 3" wide x 1/2" thick ABS rectangular bar stock. [Here are two files you can use as full scale templates - Dxf - Word97 -]. Rather than machine it, I cut it carefully using a vertical band saw. This mainly takes care and patience (not skill), plus a little time with the bastard file afterwards. The picture above shows the pieces arranged approximately as they would be prior to fastening to the mast. The two screws insert through a clearance hole on one side of the clamp, and screw into tapped threads on the mating side. I'm looking for a long shouldered screw that can be hand-turned, to replace the Phillips-head screws, but I haven't found it yet. Thus far, these are the only parts of the frame that require a hand tool. The strut fits into the mounting ears (where we have drilled 3/16 holes), two in each half-clamp, and then we use a 3/16 x 1" clevis pin and matching cotter pin to hold the struts in place. Takes about 30 seconds tops to mount a strut. Assembled like so, the struts are free to swivel during frame assembly operations.

Here's an image of the clamp assembly mounted to the mast, with struts attached. Notice how the struts are mounted using clevis pins and cotters, and how the clamp grips the mast evenly and solidly:



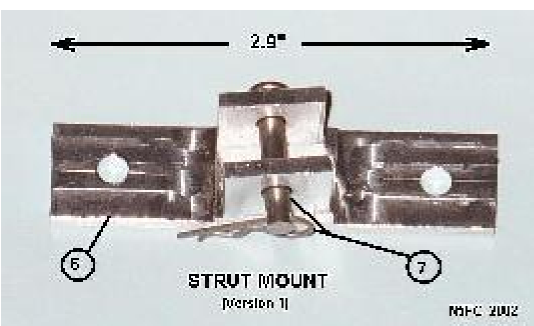
(click on the picture to see larger version)

Before we look at how the struts mount on the other side, there are two piece parts we need to understand first. Understanding these will allow us to understand how the 3-foot inner leg and 3-foot outer leg join to form a 6-foot leg. The key part is shown below:



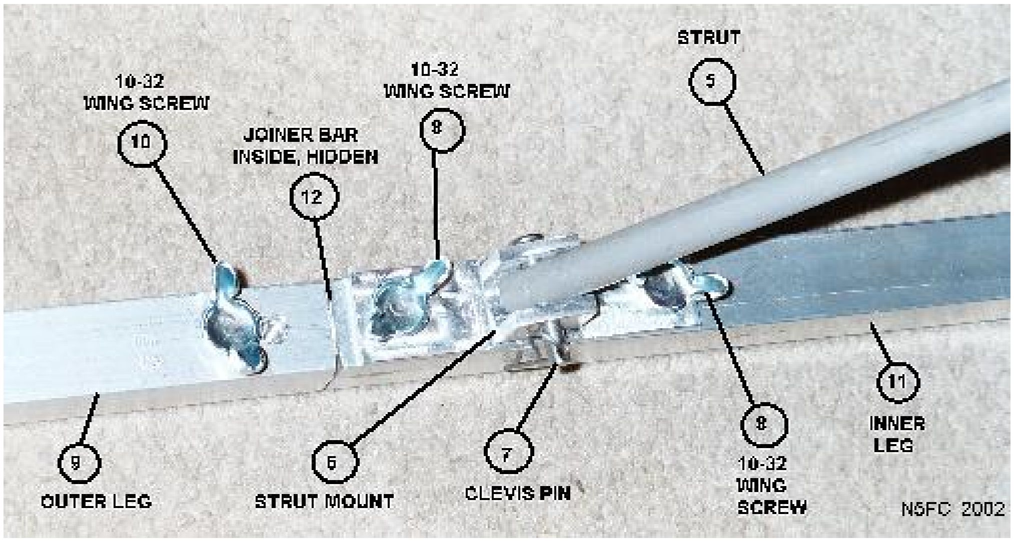
(click on the picture to see larger version)

We call the above part a "joiner bar" (clever, ain't we?). The joiner, which is threaded to accept six 10-32 screws, inserts halfway into the square tubing of the inner leg, and halfway into the outer. Again, we'll use wing-screws to fasten the legs to the joiner. But before we fasten the inner leg, we'll mount an additional piece:



(click on the picture to see larger version)

We call the above piece the "strut mount". Don't be put off by it's complexity. We originally machined this on an end mill, and then thought of a simpler way to accomplish the same thing. Using the new drawing, and a lot of care and patience, one should be able to fabricate a similar piece using a vertical band saw. CAUTION! Don't even *think* about fabricating this piece (or the clamp) using anything except a vertical band saw or a milling machine. The result is bound to be disastrous for the piece, and will likely result in injury to the "machinist". DON'T DO IT! The strut mount fastens to the inner leg, near the joint between the inner and outer leg, using two wing screws into the joiner bar (internal to the leg). Make sense? Here's a picture of the strut, inner and outer legs, and the strut mount, all assembled; the joiner bar is hidden inside the joint:



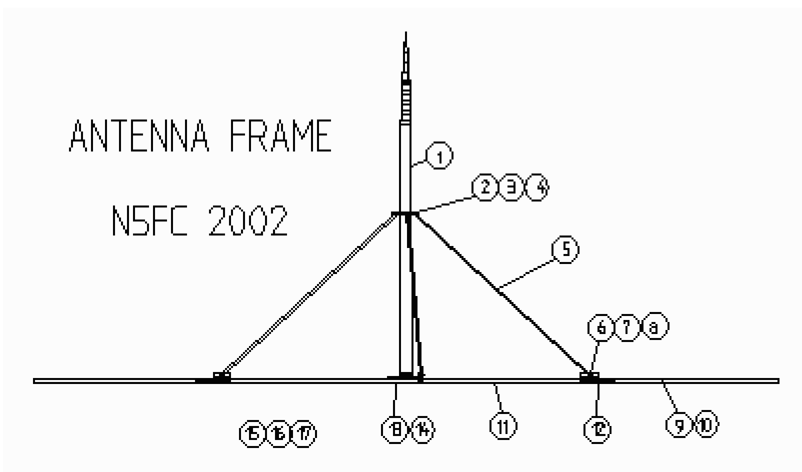
(click on the picture to see larger version)

An even closer picture of the assembled strut mount can be seen -here-.

The end of the outer leg has a 3/8" hole for general utility purposes. If you don't trust the struts and legs to fully support the antenna, or if you anticipate really high wind gust, or if you have a little too much "wind load" in your antenna, you can use round aluminum tent pegs to help secure the frame into the ground.

Drawings and Materials

Here's the mechanical drawing of the completed assembly:



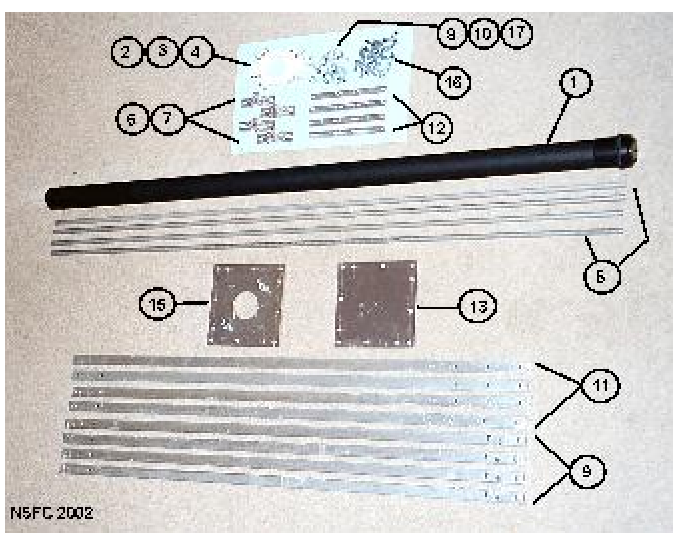
(click on the picture to see larger version)

Notice that each part is indexed by a letter (circled). These correspond to index numbers in the parts table, below. Also, where a picture of the part exists, click on that part's name (in the table, below) to view the picture. Fabricated parts contain a link to the mechanical drawing in the NOTES column.

PARTS LIST

INDEX #	QTY	NOUN	SOURCE	PART NO	NOTES
1	1	DK9SQ Mast	Kanga US		dimensions
2	2	Half Clamp, ABS	McMaster-Carr	8712K59	Fab from ABS stock, see dwg
3	4	Clevis/Cotter Pin Set, 3/16"Dx1"L	McMaster-	92390A821	5/pk

			Carr		
4	2	Screw, Pan, SS, 1/4-20x1-1/4"	McMaster-Carr		
5	4	Strut, 6061 Alum Tubing, 3/8"ODx0.035"TH	McMaster-Carr	89965K45	Fab from tubing, see dwg
6	4	Strut Mount, 2024 Alum rect bar, 1-1/2"Wx3/4"TH	McMaster-Carr	89215K317	fab from rect stock, see dwg
7	4	Clevis/Cotter Pin Set, 3/16"Dx1"L			Same as Index 3, above
8	8	Screw, Winghead,10-32x1/2"	McMaster-Carr	91510A124	20/pk
9	4	Outer Frame Leg, 6063 SQ Tubing, 3/4x3/4"x1/8"TH	McMaster-Carr	88875K31	fab from alum stock, see dwg
10	8	Screw, Winghead,10-32x1/2"			Same as Index 8, above
11	4	Inner Frame Leg, 6063 SQ Tubing, 3/4x3/4"x1/8"TH		Same as Index 9, above	fab from alum stock, see dwg
12	4	Joiner Bar, 6061 Alum SQ Bar, 1/2x1/2"	McMaster-Carr	9008K23	fab from alum bar, see dwg
13	1	Bottom Plate, 5052 Alum, 6x6x1/8"TH	McMaster-Carr	88895K1	fab from alum plate, see dwg
14	12	Nut Insert, Flush Mount, 1/4-20	McMaster-Carr	94674A533	pk/25
15	1	Top Plate, 5052 Alum, 6x6x1/8"TH		Same as Index 13, above	fab from alum plate, see dwg
16	12	Screw, Winghead,1-4-20x1-1/2"	McMaster-Carr	91510A160	pk/10; cut to length, 1-1/8" typ
17	2	Nut Insert, Flush Mount, 10-32	McMaster-Carr	94674A528	pk/25
18	2	Screw, Winghead,10-32x1/2"			for top plate, same as Index 8, above



(click on the picture to see larger version)

Field Ops

Here are some pictures of my setup in the field, during the 2002 Flight of the Bumblees QRP contest. As it was nearly 100 degrees that day, I set up in the shade of a large live-oak tree, placing the antenna frame and mast just outside the perimeter, and setting up the canvas chair in ye ole shade.




Here's an interesting aside regarding the DK9SQ mast. I originally wrapped the 33 foot wire loosely around the mast, so that my "vertical" would not be flopping around in the wind. Big mistake. Turns out the black graphite (or whatever) in the fiberglas rod is quite RF absorbent. On 20 and 15 meters, I could see a 2-3 S-unit decrease in received signal strength with the wire wrapped around the pole. And I wasn't getting out well at all, getting S2 signal reports from my Elecraft K1. But angled away from the pole (with the wire unwrapped and about 3 feet at the bottom), everything was hunky-dorey. Now I'm suddenly getting S7 reports... much better. It took me about 2-1/2 hours to realize what was going on.

Conclusions

I've been especially pleased with this project. It allows me to set up for QRP portable operations almost anywhere, without worry, and with an antenna raised to a respectable height. It's a ton of work to fabricate this oneself: all totaled, I think I have about 100 hours into it, not counting drawings and web page. There's much room for improvement, as I'm not a very clever person; I think once you really clever ones see what I've done here, you'll figure out many ways to simplify or improve it.

By the way, I'd love for someone knowledgable in mechanics to do a wind-load analyses for this frame, based on the telescoping mast, and a typical portable vertical, dipole, or loop antenna. Such an analyses is way beyond my training and skills.

Let me know what improvements you make...

73,
monty N5ESE

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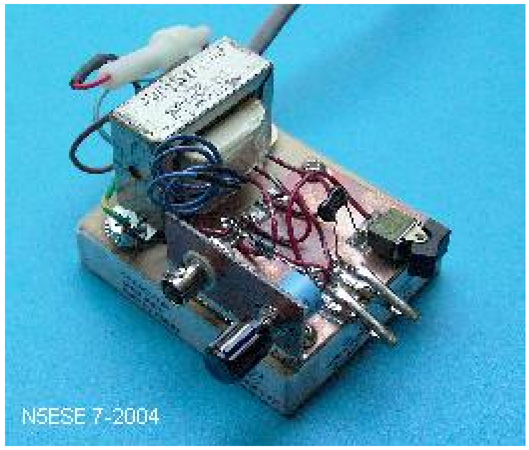
N5ESE's Junkbox Capacitance Checker

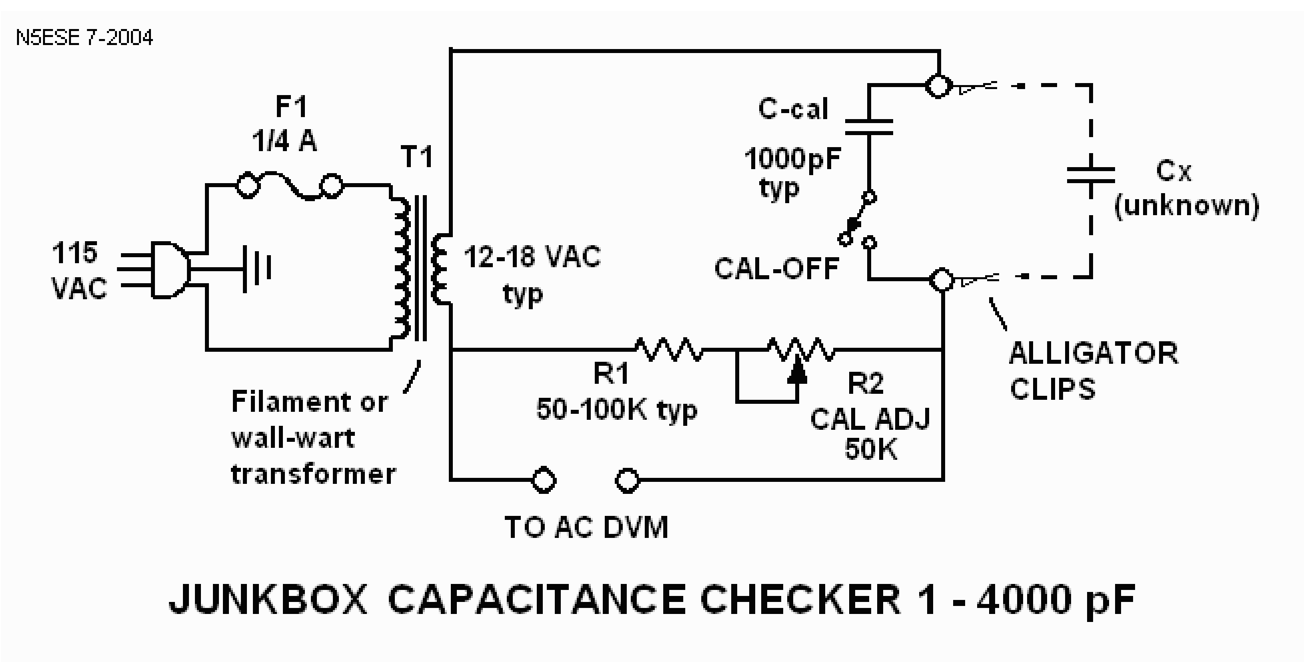


(click on the picture to see larger version)

I originally saw this circuit posted in an e-mail message forwarded to me recently. I don't know who the original author is. I built this jobber-doo in 3 hours one evening, because I wanted to see if it really worked. Wow! It works way better than I thought possible. If you have a reasonably accurate DVM (Digital Volt Meter) - say, 3-1/2 digits or better - and a few junkbox parts, you should be able to duplicate this as cheaply as I did, and end up with a truly useful and compact tool.

I could have used this on the last project I did. I had some capacitors that were labeled '270'. I coudn't tell if they were 270 pF or 27pF. [Many capacitors nowadays are marked with the last digit indicating the tens multiplier]. Murphy smiled on me that day, and I got lucky and guessed right, but I've been wrong as often on not on previous occasions. Ever wonder what that junkbox variable really is? Herer's the way to find out, quickly and accurately.

Here's the schematic:



I used a small scrap of 3/4" thick wood to mount the parts, plus a scrap piece of pc board. Layout and construction are completely non-critical. I used a transformer I had robbed previously from an old defunct modem. All the other parts I had in my junkbox. This project cost me zippo!. Fortunately, I found a 1000 pF 1%

silver mica capacitor that I had the foresight to pickup some years earlier from Dan's Small Parts for next-to-nothing. It could serve as my calibration capacitor, C-cal. I decided to use a small rocker-switch (stolen from the same old modem) to switch the calibration capacitor in and out of the circuit, thereby avoiding a loose part I had to keep track of. The switch was a pure luxury. For connecting the unknown capacitor Cx, I solder-mounted 2 spare alligator clips to a scrap PC board. This way, I could just clippy in the unknown capacitor, or another calibration capacitor, when I needed to.

The value of all parts is amazingly non-critical. I suggest a wall-wart for the transformer, to make construction that much simpler and to keep from dealing with 115 VAC wiring. Just be sure you get one with **AC** output (not DC). Anything from 12 - 18 VAC should work (mine was about 17.5V with no-load), but resistor R1 may have to be selected for best range. If you have a 500K pot, substitute it for R1 until you figure out the exact value that works best. I ended up with 50K, made from two parallel metal film resistors. I used metal film because they are more stable than the 47K carbon fiolm resistor I used at first.

To calibrate, apply power and switch in (or clip in) the 1000 pF capacitor. It helps if you have a close-tolerance capacitor like I did, or if you have one (silver mica or ceramic NPO) that you've measured on a lab instrument, because that will make your calibration all the more accurate. For a 1000pF capacitor, adjust the pot to obtain 1.000 VAC on your DVM (1mv = 1 pF). Then switch the C-cal out of the circuit. The reading you get now (depending on the quality of your DVM) should indicate the stray capacitance in your circuit. Mine indicated 3.8 pF. Remember that value, and subtract it from any reading you get on future unknown capacitors. Knowing that, I now re-calibrated the meter for 1.004 VAC (representing 1000 pF + 4 pF). Now I was ready to check a few capacitors.

I dug around the junk box and found three 1% and 2% capacitors that I could use to test the abilities of the capacitor checker. After rechecking my calibration with the 1000 pF capacitor C-cal, I measured the others. The 3000 pF 2% silver-mica capacitor measured 2956 pF, well within its tolerance. A 180 pF 1% silver mica measured 179 pF, likewise well within tolerance. I figured the circuit would not be too accurate at low values, but I was wrong. A 10 pF 1% NPO ceramic measured 9.7 pF, out-of-tolerance, but still within 1/2 pF.

I highly recommend this circuit for anyone who homebrews RF equipment. You won't be sorry!

73,
monty N5ESE

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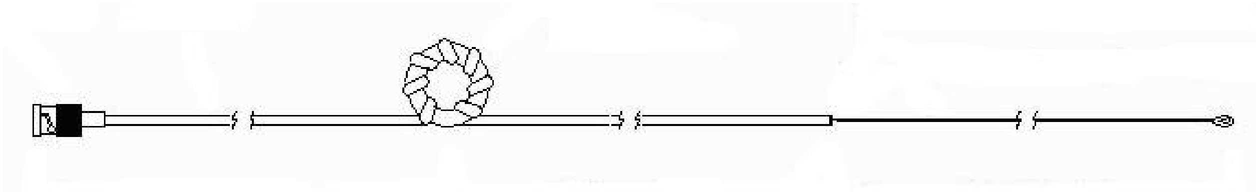
N5ESE's Look at the RFD (Resonant Feedline Dipole)



NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

Antenna Disclaimer

Right from the top of this page, I'm going to say that I'm an antenna *experimenter*, not an antenna expert. Purely seat-of-the-pants. In fact, you might even say I'm an antenna cynic. I know how to use antenna analysis tools, and I often do, but I take them with a serious grain of salt. I've found, in my 35 years of experimenting, that some antennas work much better than predicted, and some work much worse (and that they're more likely to work worse than better HI HI). Still, I find experimenting to be one of those true joys of amateur radio, and I encourage all of you to just "try it out" for yourself, and *for Pete's sake*, **don't** take my word for it (nor my explanations).

I find that most technical people do this (and I am no exception): upon observing a phenomenon, we make up an explanation for why we got our observed results. We base this explanation on the current subset of knowledge that we've gained from education and experimentation and folklore, and we're not likely to look for another explanation until we have another experience which forces us to expand or revise our previous explanation. Please realize this is the case with me, also, and then enjoy the web page.

If you *really* want to know *how it works* - without my ignorant rantings getting in the way of a thorough understanding - click -here-

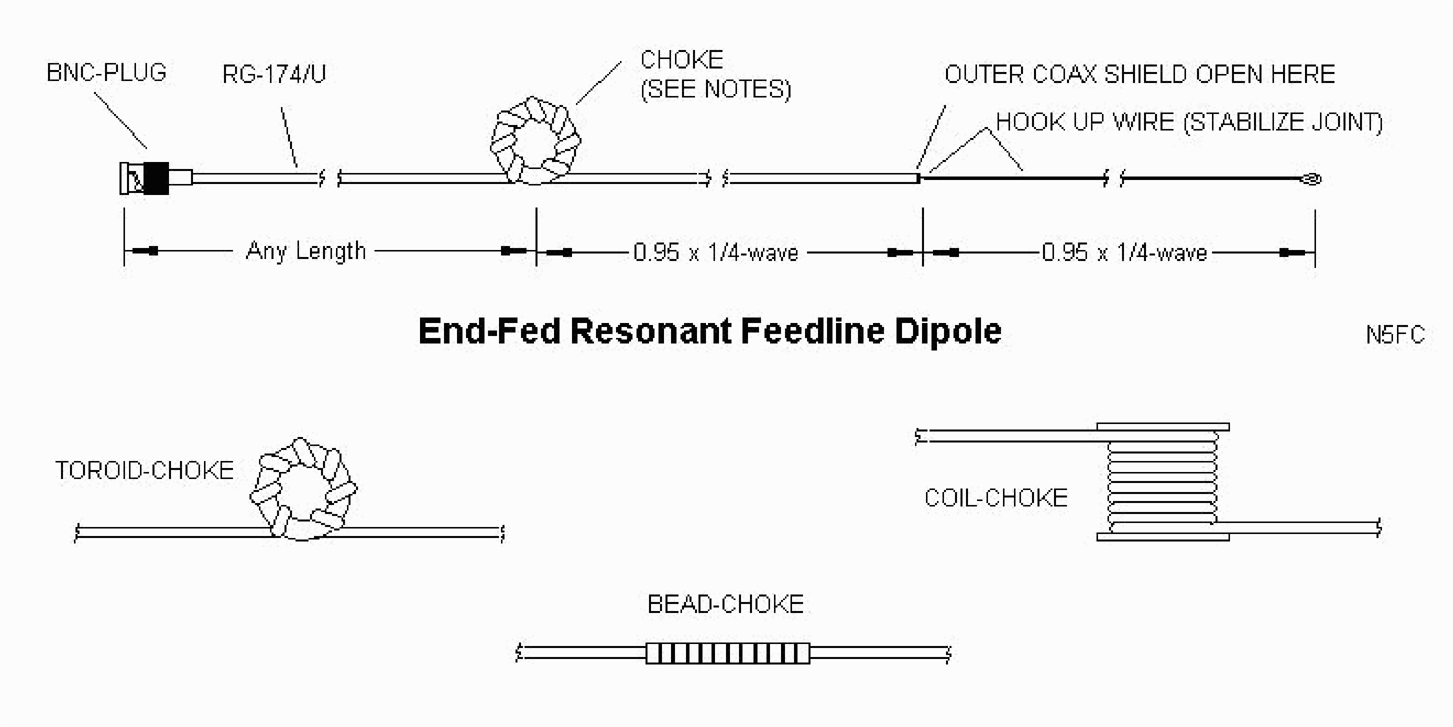
The purpose of this page is to document my personal experiences with the end-fed dipole based on the concepts presented by J. Taylor in an article titled "RFD-1 and RFD-2: Resonant Feed-Line Dipoles," in QST. August 1991. I'll leave it to that reference to expound on antenna theory, and I'll focus on my own construction methods and observations.

The Resonant Feedline Dipole (RFD) appealed to me because of my interest in portable antennas for QRP field ops. If you've ever tried to hang a center-fed dipole or doublet in a forest or trees, you'll understand exactly why an end-fed dipole would appeal. The simplest field antenna involves tossing a weighted line over the nearest high tree, pulling the wire up as high as it will go, and feeding it from the end. Wouldn't it be nice to have the performance of a conventional dipole, with the ease of installing an end-fed wire, and without having to deal with the center-feed? That's the "claim-to-fame" for the RFD. To what extent it measures up, we'll leave for the observations below. Understand, however, that the RFD-1 (described here) is a single-band antenna (though it may work on the third harmonic), unlike the center-fed doublet, which will often tune all-bands (with an antenna tuner and a judicious choice of feedline).

NOTE: You might also look at the site of KO4WX, and look for his online article titled "Revisiting the Resonant Feedline Dipole" in which Mike Boatright describes yet another approach to constructing the RFD.

Construction

Here's a basic diagram of the RFD:



In the above sketch, please note that the active (hopefully, radiating) portion of the antenna (on the right) consists of an electrical half-wavelength. Like a dipole, the RF current maximum is at the center of the half-wavelength, making it a "dipole". The "center" (or rather, center-equivalent, if we can call it that) is the point where the coax ends and the center conductor continues to the right. We do indeed have a feedline connected to this point (our feedline coax), but we require the choke at 1/4-wave to the left of the "center" to force the RF to flow correctly on the outside of the feedline, so that it acts like a dipole. The "choke" is the element that peforms this magic for us. In this context, a "choke" means an electrical element that serves to "choke" common mode RF at that point. That is, the choke looks like a very high impedance to the RF currents reflected from the center discontinuity (where the feedline abruptly ends in an open-circuit), and traveling down the outside braid of the coax. The extent to which the choke element does its job -- and its location electrically from the dipole "center" -- determines how well the RFD works, and what impedance will be seen by the rest of the feedline, extending to the left of the choke. Nominally, if all goes well, the impedance seen by the feedline will be near 50-ohms (and this is the characteristic impedance of the feedline we should use in construction). This makes the RFD suitable for readily available coax types RG-174, RG-188, RG-58, RG-8M, and RG-8 (though RG-8 is a little stout for a portable antenna).

There are three important points to be emphasized here, to avoid confusion. First, there is physically only one single contiguous feedline, and it extends from the connector on the left, through the choke, to the "center" discontinuity. Second, the feedline may be any random length leftward from the choke (assuming we have a good choke and locate it correctly). Third, the coax shield is open at the "center" discontinuity; i.e., it is NOT shorted to the center conductor or to the wire extending rightward.

As illustrated above, three basic types of choke constructions might work for us: the toroid-choke, the coil-choke, and the bead-choke. The toroid-choke consists of a medium-to-large-sized ferrite toroid, with several turns of the feedline around it. Because of the difficulty of forming turns of coax around a toroid, this method is probably only practical for small-diameter, flexible coax, like RG-174. The coil-choke is the choice used by the original designer, J. Taylor. It consists of a single-layer solenoidal winding, close-wound (NOT scramble-wound). The bead-choke consists of several adjacent ferrite beads placed on the outside of the coax (usually 15-25).

In the case of the toroid-choke and coil-choke, there will be distributed capacitance as a result of the coaxial windings, one turn to the next. There will also be an inherent additional inductance in the inner conductor of the coax, as a result of the turns. While one may consider these to be "stray", parasitic, or unwanted reactances, Taylor points out that these may actually contribute toward forming a parallel-resonant circuit at the choke-point, thus improving the "choking" effect (which is essential). I did not investigate this aspect of the choke, although the original article suggested ways to predict and use it when using the coil-choke construction.

Experiments and Observations

(click on the image above to see a larger image)

The image above is the first version I built. This one used RG-174 miniature 50-ohm coax in it's construction, and was constructed for the 15 Meter CW band. The feedline was terminated in a BNC plug, which you can see loosely coiled for storage at the left. I allowed about 3 feet for "feedline" (to the left of the choke). The "choke", which is the second coil of wire from the left (with 4 pieces of white tape), consisted of 8 turns of the feedline coax, with a diameter of roughly 3-1/2 inches. This was scramble-would (which turned out to be a less-than-optimal). From there, you can see approximately 11 feet of the remaining feedline coax (extending rightward from the choke). At that point, I cut the shield back, leaving about an inch and a half of center conductor extending out. I heat-shrank tubing over the outer shield cut, to seal it and prevent shorts with the center conductor. I then connected and soldered 11.1 feet of hookup wire (actually superflex insulated antenna wire, AWG 26) to the center conductor. For mechanical strength and electrical insulation, I folded this wire back against the insulated feedline, and heat-shrank more tubing over the entire joint (electrical tape would work as well). Then I formed a small loop at the end of the hookup wire for pulling the antenna up into the trees (or whatever its supporting structure might be).

I was eager to test the antenna. I hauled it up from my regular base-station 33 foot mast, until it was suspended like a sloper, with the bottom end (BNC plug) in my hand, connected to the antenna analyzer. I surmised that I could "roll" the choke back and forth enough to achieve the lowest SWR on my MFJ Anetnna analyzer, but the lowest I could achieve was about 2.5:1.

The first mistake I encountered in construction was in calculating the length of the 1/4-wave feedline between the "center" discontinuity and the choke. I assumed that I should apply the velocity-factor of the coax (roughly, 78%) to determine the physical length of the quarter-wave section. However, I soon discovered empirically, that the RF currents being choked flow only on the outside of the coax, and are subject only to the dielectric effects of the outside insulation, much like the effect of using insulated hookup wire versus uninsulated wire. Thus, instead of a velocity factor of 78%, expect something in the range of 95%. So the correct distance from center to choke ended up being near 11 feet (246 * 0.95 / 21.060 = 11.096 ft)

The second mistake was scramble-winding the choke. Apparently, the extra distributed capacitance served to undermine the choke's effectiveness. I then went and found a piece of 4-inch diameter cardboard shipping tube, and re-formed the choke into side-by-side winding (solenoid winding). After doing so, I was able to achieve a 1.7:1 SWR. The distance (from the "center" to the choke) turned out to be somewhere within a foot of the predicted 11 feet (but closer to 12).

I tried this antenna on several outings to my daughter's house in Waco, with the antenna hoisted about 20 feet at the far end, and feeding directly into a NORCAL BLT tuner, then via short coax to my TenTec 1315 CW Transceiver at 3 watts. Results were disappointing. While I did not do a side-by-side comparison, reports were consistently down from previous experiences with a short random-length wire and the same antenna. Still, I was able to make QSOs, though often with S3 and S4 reports, and rarely would a CQ bring a response.

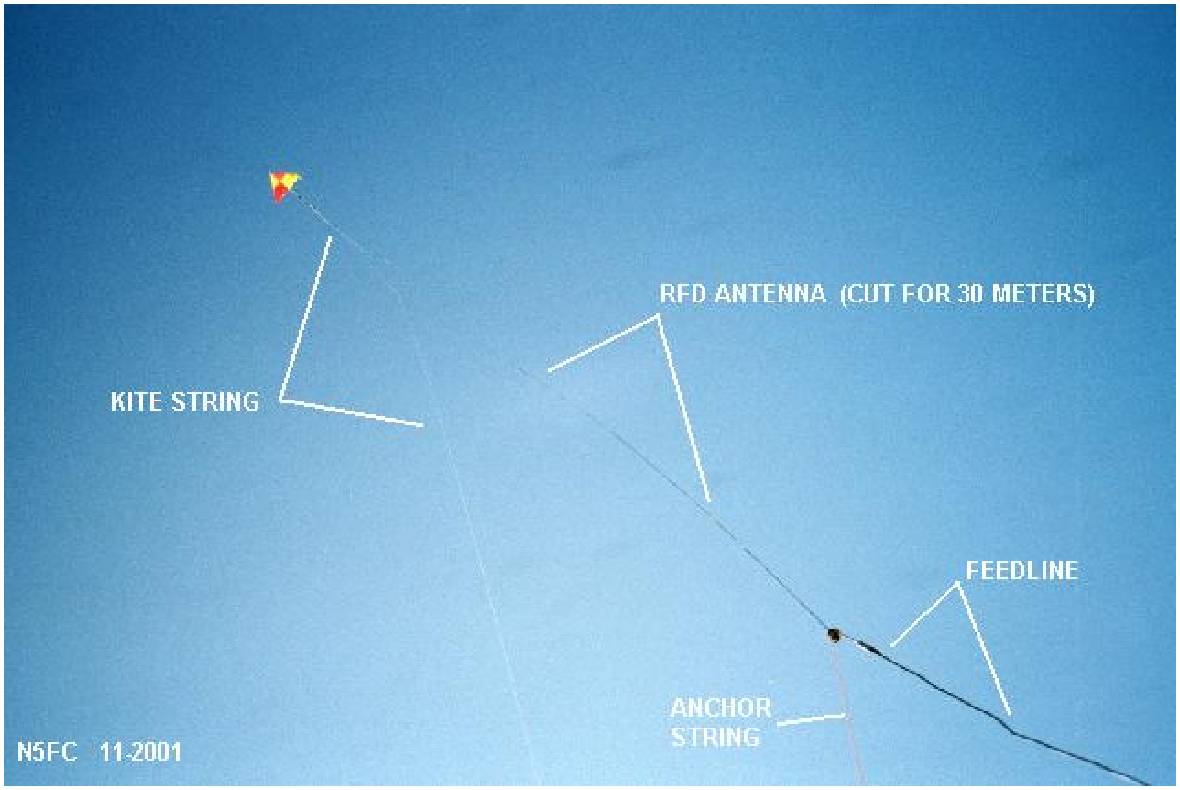
I speculated that the RG-174 was extremely lossy at this frequency, so I went about creating several other versions. The first was a 30-Meter version using the same construction technique. An image is shown below (but the image shows a scramble-woulnd choke, later changed tto solenoid-wound):

(click on the image above to see a larger image)

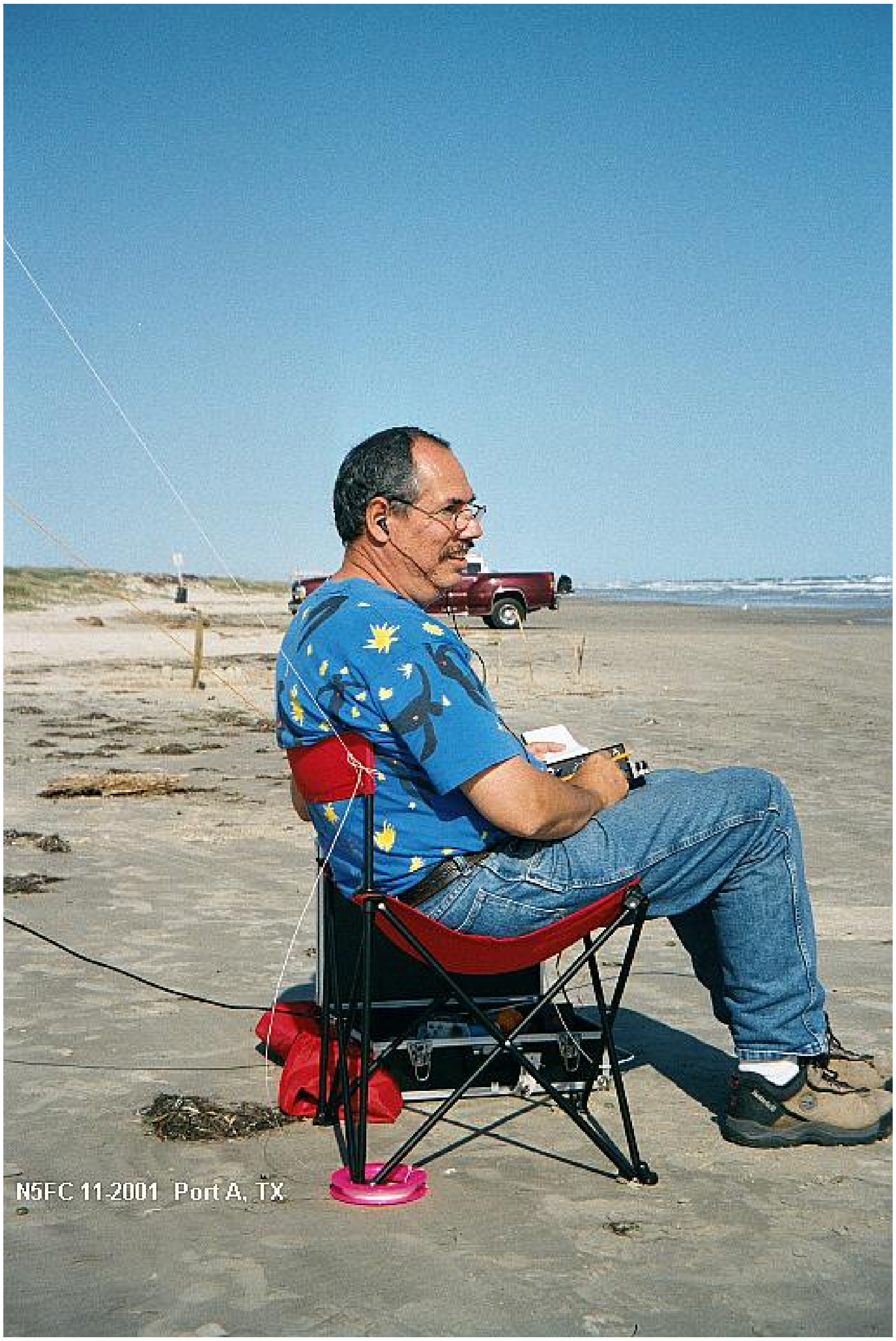
For this version, I continued to use RG174, but increased the choke turns to 12. On initial testing, this one did not behave as I expected. With the outer "leg" cut to 23.1 feet (246 * .95 / 10.110), and expecting the distance from "center" to choke to be just a little more than that, I had to wind the choke all the way out to the BNC connector (about 30 feet choke-to-center) before I fell as low as 2.2:1 SWR. Had I more feedline, I might have gotten it a little lower. Still, I tried this again at my daughter's house, using the BLT tuner and TenTec 1330 transceiver at 4 watts, and got results very similar to those encountered on 15 Meters, i.e., disappointing signal reports.

It was now time to try a different choke. Re-using my previous RG-174, 30-meter antenna, I dismantled it to install a toroid-choke. I wound 7 turns as tightly as I could onto two stacked FT114-43 ferrite cores. Because it would be fairly difficult to move a core like this up and down the feedline, I decided to place it at the predicted spot (0.95 * 1/4-wavelength from "center") and take whatever I got. What I got was a 2.5:1 SWR, and about 12 feet of "leftover" feedline (which used to be in the coil-choke).

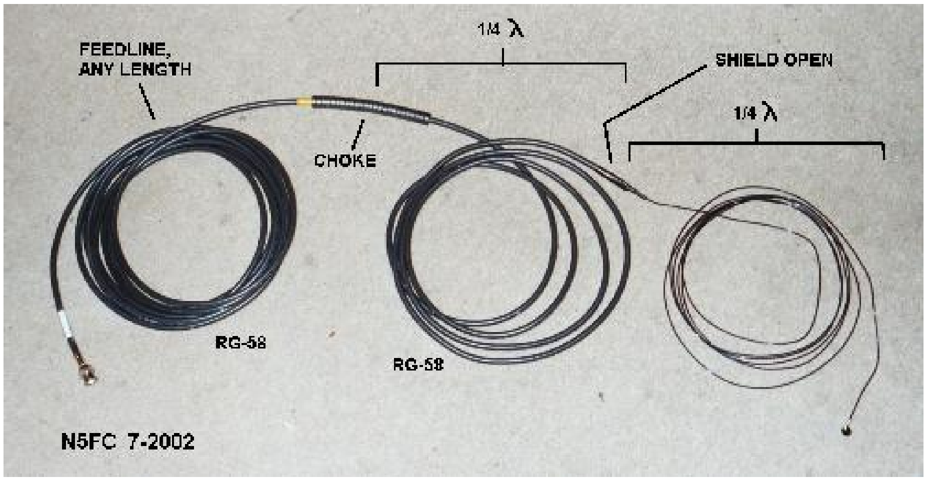
This was about the time we would be vacationing at Port Aransason the Gulf Coast of Texas, and I took the opportunity to deploy this version on the beach for daytime ops. Here's the antenna, deployed:



I procured my XYL's favorite kite to hoist the RFD antenna, and used some stouter nylon twine to anchor it into the beach, tying the twine to the choke to make sure the antenna wouldn't get away. The kite raised it to near-vertical, with the BNC end again going to the [Emtech](http://www.emtech.us) ZM-2 tuner and the TenTec 1315 at 3 watts. Results were tolerable (in other words, I managed QSOs), but at least one S unit (and maybe closer to two) down from a 33 foot vertical wire and counterpoise I used the following day. Here I am in QSO in the beach:



The next thing to try, because it would allow larger, less lossy coax, and allow more readily adjusting the position of the choke, was a bead-choke. For this, I constructed a 15-Meter version using RG-58 cable, with 25 each FT50-43 ferrite beads for a choke. Here's a picture of the completed antenna, loosely coiled for display:



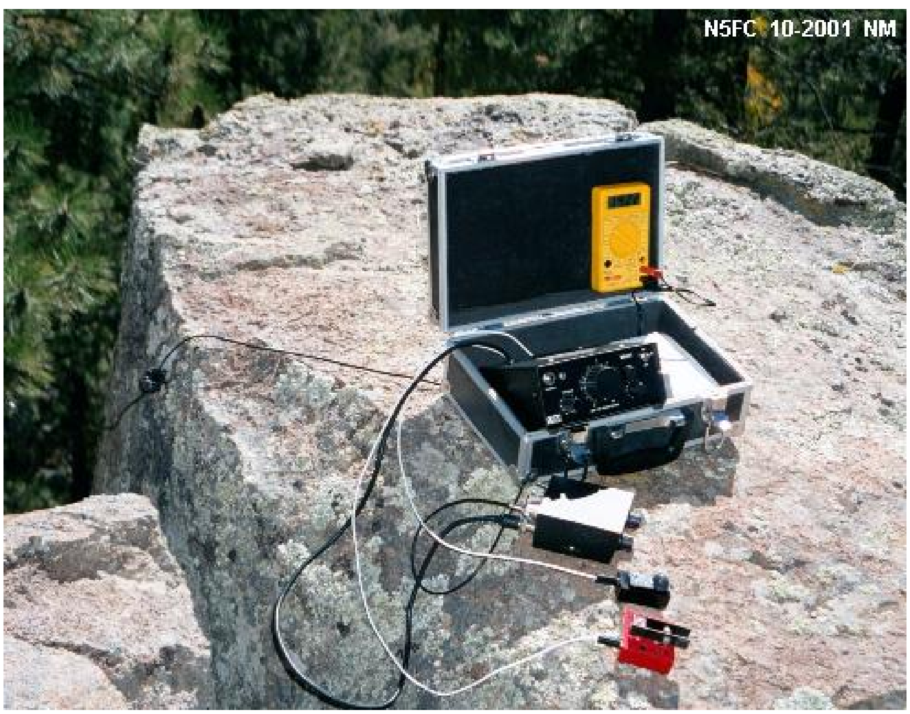
(click on the image above to see a larger, annotated image)

You can view a detail of the center-joint -here- and a detail of the bead-choke -here-.

I was quite hopeful for this version; in fact, I was so sure it would work, that I built versions for 40, 30, 20, and 15 before even testing them. But once again, I was disappointed in the results. In this case, for all versions, I could not find a location where the SWR dropped below 2.5:1, and the point at which it dropped to it's lowest SWR was quite ill-defined, being 100 - 120% of the nominal quarter wavelength (choke-to-center). At this point, I was sufficiently discouraged that I gave away my RFD's to members of the Austin QRP club, in hopes that one of them might figure out a way to make them work better.

Conclusions

While experimenting with antennas is always fun (and this was no exception), I cannot recommend these antenna designs for portable QRP use. This is not to say you won't get a signal out. On one field trip to a mountain top in the mountains of norther New Mexico, perched on an outcropping at 8700 feet, with the 15 Mter RG-174 version of the RFD suspended as a sloper to a fir tree, I was able to QSO a JA for 15 minutes, using a TenTec 1315 transceiver at two watts on internal batteries. Here's a picture of that deployment:



(click on the image above to see a larger image)

You can see the toroid-wound choke laying on the outcropping. Notice, I'm still using an antenna tuner (the NorCal BLT). But recall, one of the advantages of the RFD was suposed to be not needing one. I suspect my sucess had more to do with the location than the antenna. Still, it did work! And what a view!

Based on my experiments, if an end-fed antenna is called for, a random length of wire and a counterpoise (along with a suitable antenna tuner) will probably serve you better. Certainly, this antenna (even though it's called a "dipole") does not perform as well as a center-fed dipole in the same configuration, nor as well as an end-fed half-wave likewise configured. Sorry, Charlie!

73, monty N5ESE

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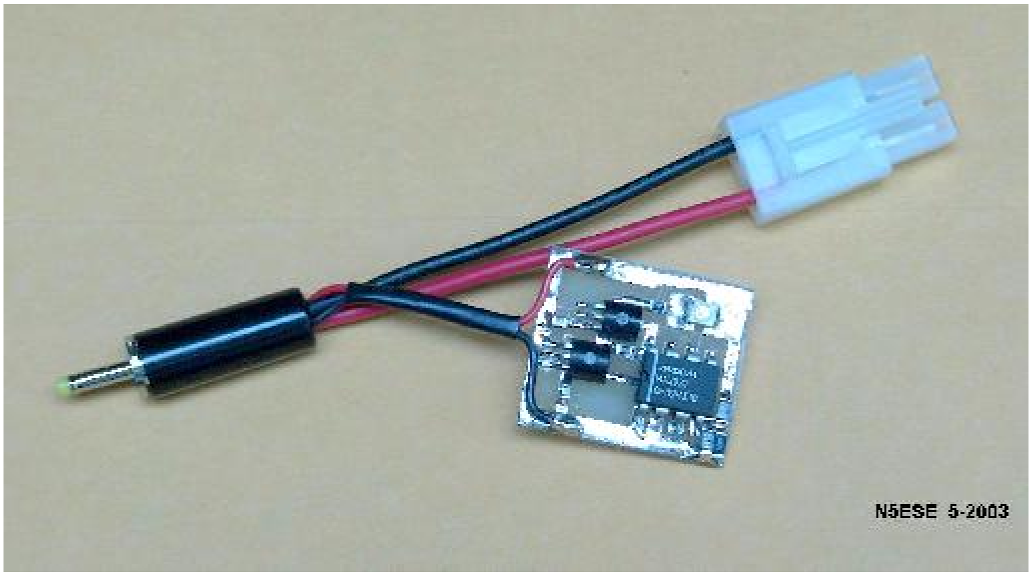
N5ESE's Low Battery Warning Gizmo



(click on any picture to see larger version)

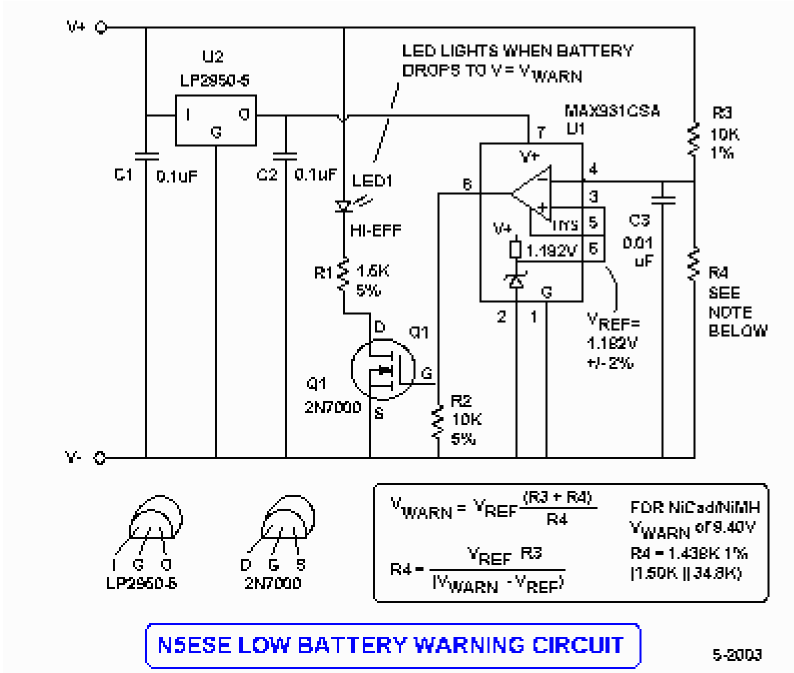
NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

When I built the KD1JV AT-Sprint (a 3-band, 5-watt CW Transceiver with DDS VFO) into an Altoids tin, I wanted a battery pack that was worthy of it. It seemed silly to haul around a 7AH 12 Volt Gel Cell that was 8 times the weight and volume of the AT-Sprint. After looking around, I discovered 9.6 Volt NiCad/NiMH packs, the kind made for powering radio-controlled cars. They were inexpensive, rechargeable, and about the same volume as an Altoids tin. And because the AT-Sprint is so efficient in transmit, a single pack would last 4-6 hours of casual operating (longer than I usually last on an afternoon outing).. I bought a NiMH type, along with it's 4-hour charger, charged it up, and went on my first portable QRP outing. I got a rude awakening right about 4-1/2 hours when suddenly things started acting flaky and within seconds I was off the air, mid-QSO. Turns out the battery had "kneed-over" as NiMH and NiCads will do, and left me stranded. You see, these type batteries maintain near full output voltage until they are nearly drained, at which time they rather quickly begin dropping voltage.

What I needed was an accurate low-voltage warning circuit precise enough to monitor the battery voltage for that predictable point just before it "knees-over", giving me a warning that would allow me to sign-off and complete a QSO. What I present here is just such a circuit, which typically gives me at least 15 minutes before the ominous moment when "there it goes".

My Approach

I decided that a simple LED warning, located somewhere near the rig, would be all that was required to notify the op. What would be required is a circuit that constantly monitors the battery voltage, and if it reaches that magic low-point (9.40V for NiCADs and NiMHs), it turns the LED "ON". Such a circuit would have to be micro-powered; that is, it draws next to nothing from the battery itself, so it may be left in the circuit continuously without adversely affecting battery reserve. We decided on the circuit shown below:



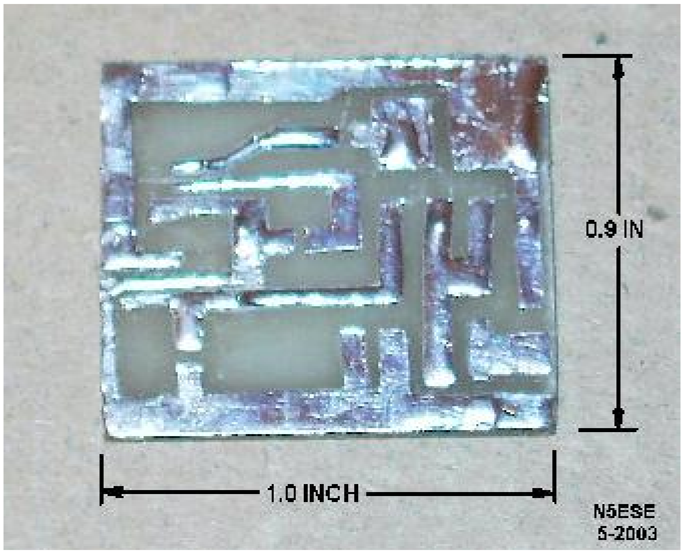
(click on the image above to see larger version)

All the parts can be had from Digikey. The MAX931 is a nifty little 8-pin IC which contains a single comparator and a built-in temperature-compensated voltage reference. (They also make versions with 2 and 4 comparators in a single package, good for "window" comparators, and high-low comparators). The comparator takes the internally generated 1.182 Volt reference as its reference, and takes a sample of the battery voltage (via voltage divider R3/R4) as the signal to be compared. If that sample falls below the reference voltage, the comparator's output drives Q1 (2N7000) gate high, forcing it's drain to ground, and lighting the LED. U2 is a micro-powered 5-Volt regulator, for powering the comparator, whose max supply voltage is 6 Volts.

At the bottom of the schematic, you'll see the formulas for figuring out V-WARN, the battery-low-warning voltage, according to the voltage divider R3/R4, and you'll also see the converse; that is, formulas for figuring out R4 when you know what V-WARN you want, Thus, you could design this circuit for any battery pack you use (above 6.2 Volts), be it NiCad, NiMH, Gel Cell, Conventional Lead Acid, or ???

Construction

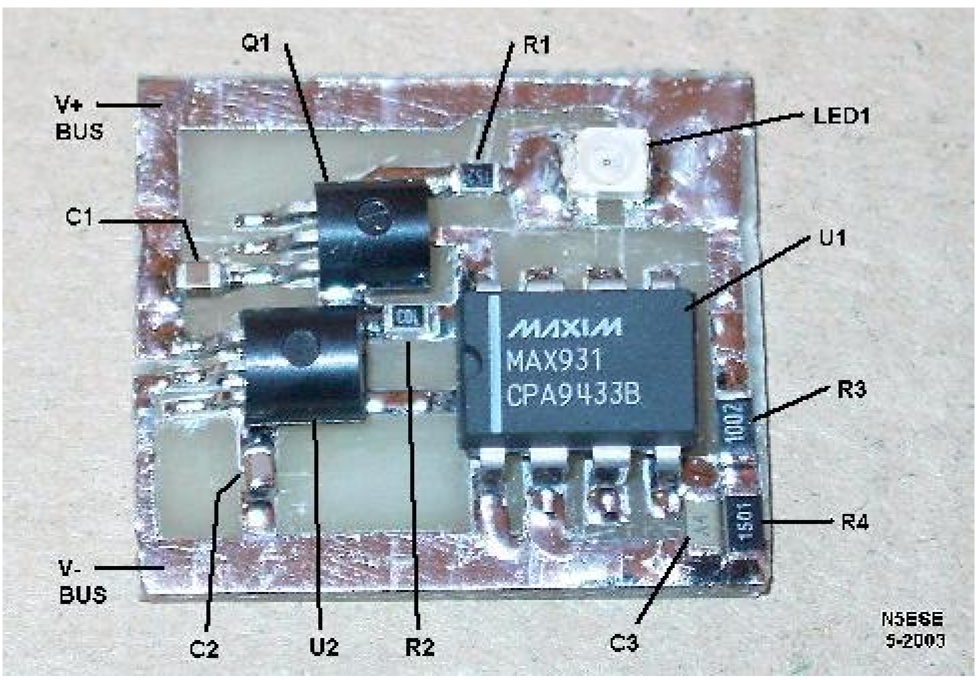
In keeping with the spirit of the AT-Sprint (which is 95% surface-mount), we decided to build this circuit using surface-mount techniques throughout, even though some of the parts are through-hole parts. This isn't hard to do. After a little planning with a pencil and a greasy yellow sheet of paper, we grabbed our hobby knife and a small 1 x 0.9-inch piece of raw scrap PCB, and proceeded to make our printed circuit. I am fond of the technique I use, dubbed by the late Doug DeMaw W1FB as "cut and peel". It's easy - you decide what doesn't belong, you cut around those edges carefully, and you lift up the copper, which "peels" off the board (with practice).. What I end up with (after tinning with a soldering iron) looks like this:



(click on the image above to see larger version)

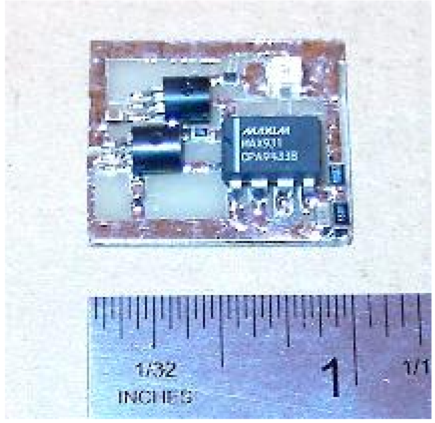
The real beauty of surface mount, is that there are no drills! Ever try to drill a small board like this? It ain't fun, and I always seem to mess up a hole or two or wipe out a trace.

When you go to assembly, you simply align the part carefully on its pads, and apply a teensy-eensy bit of solder (beginners ALWAYS use too much solder, and I confess some of the joints you'll see here are globbed on a bit too much). Here's a view of the completed board, annotated with reference designators from the schematic. R4 consists of two resistors in parallel, stacked one on top of the other.



(click on the image above to see larger version)

Is it really that small? Check out the picture below:



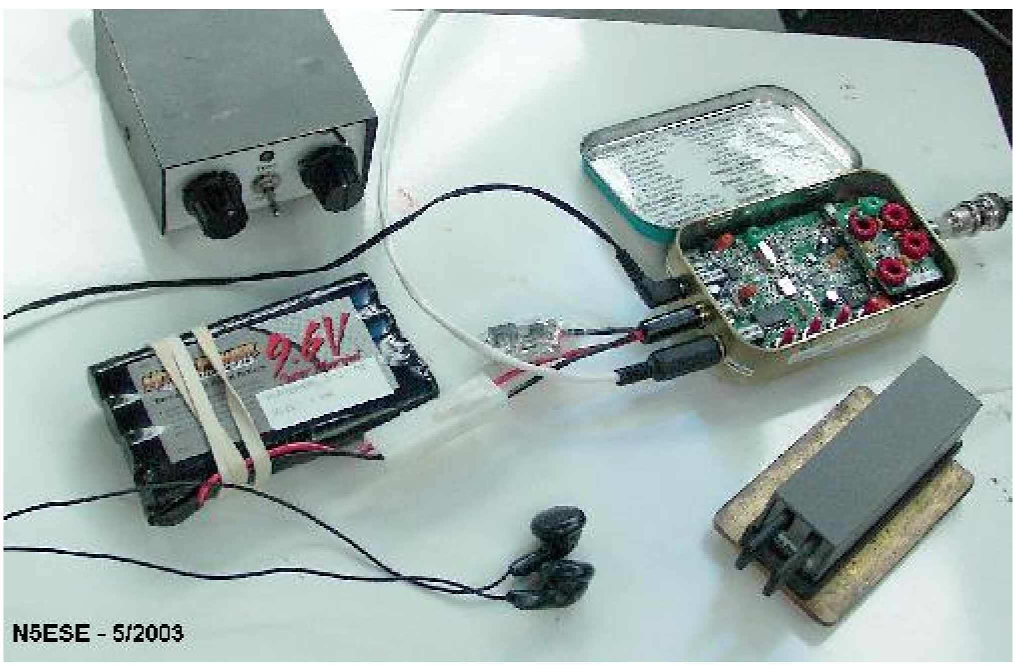
(click on the image above to see larger version)

We ended up installing this little gizmo onto an adapter cable that goes from the battery pack to the connector that the AT-Sprint uses. You can see a picture of it at the top. Before we went to the field, we took some clear plastic and wrapped the board in it, so that it wouldn't inadvertantly short to something, yet we can still easily view the LED.

The "Put Up"

Fact is, this little baby works great! Next field trip, after about 4-1/2 hours, we noticed the LED blinking in sync with my keying. In about 10 minutes, I had wrapped up my QSO, and in about 5 more minutes, the light turned on continuously, and five minutes later, the unit died. Perfect!

Here's a picture of the whole setup deployed in the front seat of my car. You'll have to look closely, but I think you can find the battery warning gizmo.



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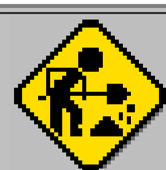
N5ESE's Outboard T/R Switch
For QRP "Separates"

(click on any picture to see larger version)



I normally don't post projects of immature design here. But I originally built this in February of 2006 and simply haven't had the time to tweak it to perfection. Almost a year after it's initial testing, it still sits on the back of the bench. Sigh. I wouldn't hesitate to use it on-the-air, but I'd nonetheless welcome others to duplicate and/or modify it, especially so as to improve the on/off ratio of the T/R switch itself. Let me know how it goes...

First Things First

I didn't originally realize it, but the more I think about it, the more I think the idea for this grew out of some discussions I had with my friend Dan Tayloe, N7VE. Aside from being a die-hard homebrewer like myself, Dan is an accomplished and recognized RF Engineer. In fact, a circuit eerily like this is used in some designs (like the NC2030 and the FireFly transceivers) that were engineered by him more than a year before I slapped mine together. At any rate, I'd like to publicly thank **Dan Tayloe, N7VE** and **Steve Weber, KD1JV**, for the many ways they have inspired my own homebrewing adventures, as well as for the myriad ways they have enriched the experience of homebrewers and kit builders in the QRP community at large. To both - *Salud!*

A New T/R Switch Idea?

There are a lot of discrete tramsmitter and receiver circuits out there, in print and on the Internet, targeted at the QRP builder. Alas, these "standalones" rarely address the transmit/receive issue adequately. I remember a few years ago, eager to test my "Altoobs" design, and swapping BNC cables back and forth to switch between transmit and receive, and enduring unbelievably loud sidetone in an unmuted receiver. It's not that the receiver was incapable of muting - it was that I didn't prepare a suitable T/R circuit for it.

The project I present here is my attempt at a universal QRP T/R switch. The idea is to take care of the essentials, so that any QRP (i.e., less than 10W) receiver ***AND*** CW transmitter can be connected, and work seamlessly. These are what I considered the "essentials" to be:

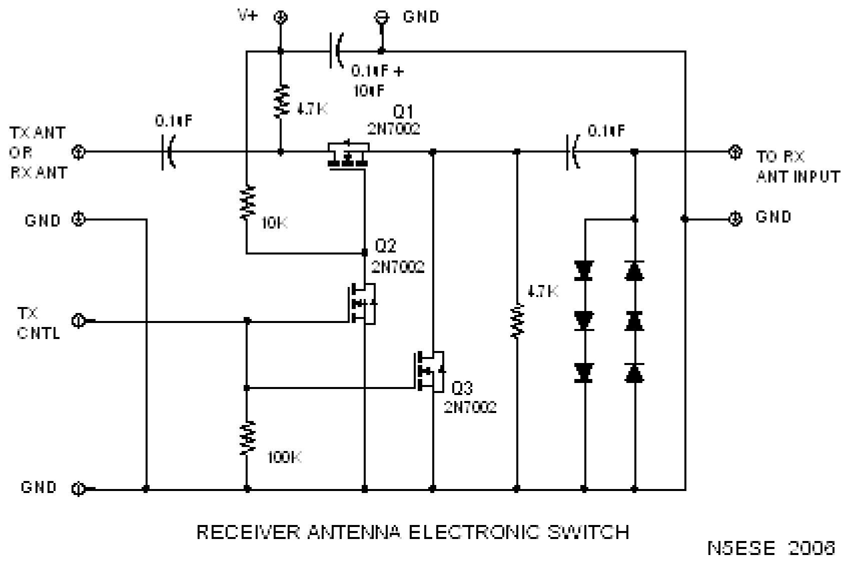
- The transmitter RF Output is always connected to the antenna (i.e., not switched);
- The T/R Switch switches the receiver OUT of the transmit (antenna) circuit;
- The T/R Switch protects the receiver from excess signal during transmit
- The T/R Switch accepts the key input;
- The T/R Switch keys the transmitter;
- The T/R Switch provides a mute signal for the receiver;
- The T/R Switch provides a sidetone signal for the receiver;
- The T/R Switch provides all sequencing for full and automatic QSK (break-in) CW;
- The T/R Switch is independently powered, and efficiently so.

The operational scenario would be as follows, and could easily be applied to any QRP transmitter (or transceiver used as a transmitter) and any receiver (or transceiver used as a receiver). But the device is especially designed to accommodate a simple transmitter and receiver, each having few embellishments, and requiring none. Operationally, here's how a typical case would work:

- Using a "tee", connect the T/R Switch to the Transmitter-Antenna Coax (50-ohms)
- Connect the Receiver Input (i.e., antenna) via coax to the T/R Switch
- If the receiver has a "Mute" input, connect it to the T/R Switch
- If the receiver has a "sidetone" or "aux audio" input, connect it to the T/R Switch
- Connect the key (any type) to the T/R Switch
- Connect the T/R Switch "key out" to the transmitter's "key in"
- Power the T/R switch (9-Volt Battery)
- Operate at will

Nice, But How Are We Going To Do It?

When Steve Weber, KD1JV, used three 2N7000 power MosFETs in the final of his AT Sprint transceiver, and managed to produce 6 watts with same (4W at 20 Meters), it really opened my eyes to these little devices. I had always thought of these as audio or power-control devices, but now I began to think in a different direction. One thing that immediately occured to me is that these devices might be configured in such a manner as to provide an "on/off" switch to RF energy between the transmit line and the receiver's antenna input. They could additionally provide protection to the receiver, by shunting any unwanted energy that might make it as far as the receiver's antenna input. This led to some experimenting in SPICE, and eventually to the following essential T/R switch circuit:



(click on the above image to see a higher-res version)

Let's review the schematic. The transmit signal is tapped at the transmitter output - the transmitter remains connected to the antenna at all times - and arrives at the left "TX-ANT" port. Q1 serves to connect the receiver antenna port (right, "TO RX") to the antenna (during receive), or isolate it (during transmit). Because Q1 does not completely isolate the transmit signal (because of device leakage), Q3 serves to short the receiver input during transmit. The array of diodes clips any signals that may arrive during receive periods, and limits any voltage presented to the receiver antenna input to about 4 Volts peak-to-peak. Q2 is the control buffer for Q1. A "high" control signal to the "KEYNOT" port (from the control circuitry, representing the "key-down" i.e., transmit condition)) causes Q2 to turn ON, Q1 to turn OFF, and Q3 to turn ON. Conversely, a "low" control signal (the key-up/receive condition) causes Q2 to turn OFF, Q1 to turn ON, and Q3 to turn OFF.

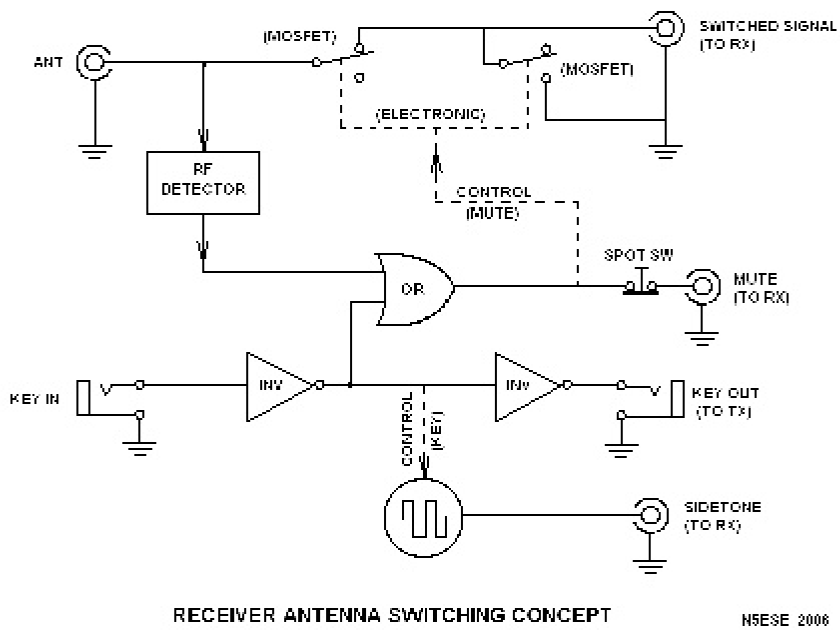
I won't belabor the details of the SPICE analysis, but you can see at least partial results in a whitepaper -here-. The challenge, for those of you who are interested in improving the circuit, is to improve the OFF condition, so that it really does isolate the receiver from the transmit line, all without significantly affecting the transmit impedance or transmit power. In real world measurements, at 30 Mhz, we are only seeing about 18 dB of isolation. Lower frequencies are considerably better, on the order of 30-36 dB.

Another challenge is to protect the switch itself (Q1) from high voltage due to high SWR (for example, from transmitting into a bad mismatch or missing antenna). I've not yet encountered that condition, but it could potentially be catastrophic to Q1. Avoid the temptation to protect it with a zener, as the capacitance in the zener may actually degrade the isolation further.

FLASH! *Dan Tayloe, N7VE, suggests the BSS123 as a substitute for the 2N7002. On reviewing the data sheets, it looks like it could add some much-needed design margin to the T/R Switch. With a Drain-Source rating of 100V (versus 60V for the 2N7002) and about half the capacitances, it should perform at least as well, and maybe even improve the isolation, to boot.*

By the way, you may have noticed that the TX ANT port (left) is also labeled RX ANT. You are free to connect a separate receive antenna, and the device will still provide isolation from coupled energy.

You've probably already noticed that a bunch of features that I listed earlier are not implemented in the above circuit. These are provided by the control circuitry. Here's a conceptual block diagram of what we are attempting to accomplish:



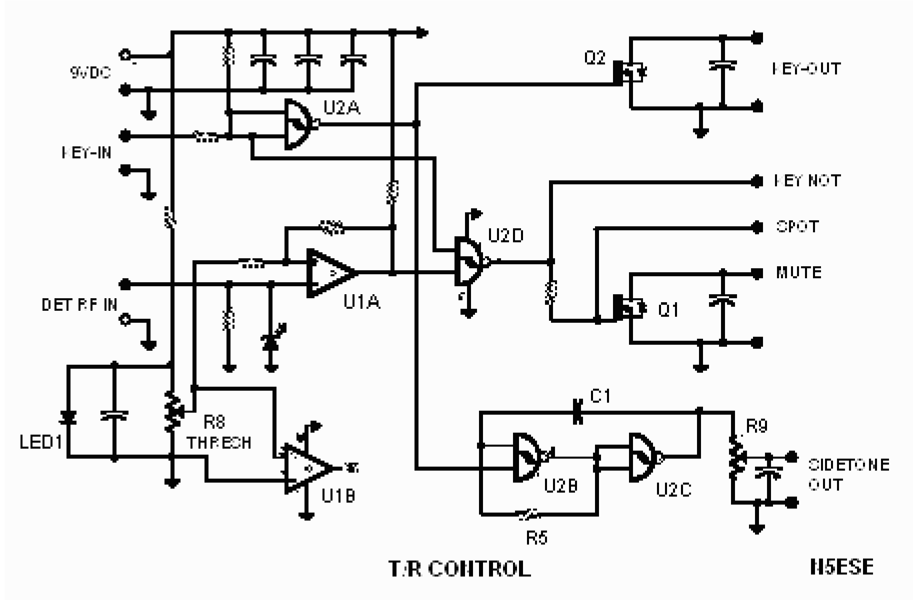
(click on the above image to see a higher-res version)

Keep in mind, this is a functional, conceptual layout. The first thing you'll notice, in the upper right corner, are the RF switches, corresponding to Q1 and Q3, discussed earlier. The control signal for those switches (shown as dotted lines) is developed from one (or both) of two input signals: the keying input, and/or the RF detector. Normally, the keyline controls the condition of the RF switch circuit, but what would happen if the transmitter were keyed from a front panel switch, instead of from the key? The RF Detector would detect the presence of RF and immediately disconnect the receiver input.

The RF Detector also assures that the T/R Switch remains engaged for that few milliseconds *after* the key is released, in which the tranmitter is still producing RF. In fact, however long that takes, the RF Detector will keep the T/R Switch activated. On key-down, the keying circuit immediately activates the T/R Switch, before the Transmitter has actually generated RF. On key-up, however, the RF Detector makes sure the T/R switch stays activated. In this way, we don't have to create a complex sequencer to produce a particular on-delay and off-delay. This approach assures universal application without having to know the timing characteristics of a particular transmitter's keying circuit.

Two ancillary functions are provided by the control circuitry also. A keyed sidetone oscillator provides audio for injection into the receiver. In a typical simple receiver project, the addition of a resistor at the audio amplifier input is all that is required to add an auxiliary audio input. Many older commercial receivers already have such an input (as well as a "ground to mute" input). Lastly, a spot function is provided to disable the mute so that the actual transmit signal can be monitored, for zero-beating.

And here's the actual control circuit:



(click on the above image to see a higher-res version)

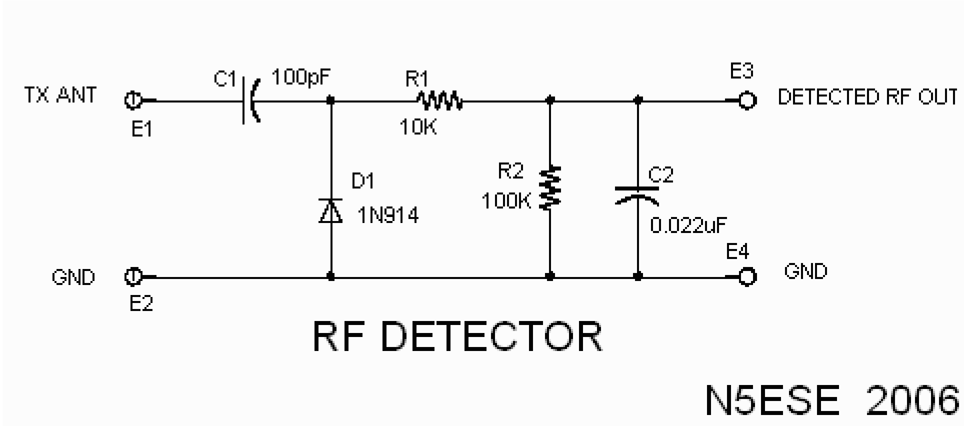
In the schematic above, NAND Gate U2D serves to "OR" the keyline and detected RF to drive power mosfet Q1, our muting switch. The mute signal is an output to the receiver, optionally used, which provides a ground when the transmitter is expected to be active. The signal which drives transistor Q1 also gets routed to the KEYNOT control input on the RF Switch board, activating those switches to the "transmit" condition (thereby isolating the receiver from the antenna).

NAND Gate U2A serves to buffer the keyline, and drives our output keying transistor Q2, which keys the transmitter. U2A also keys our Sidetone Generator, a 650 Hz relaxation oscillator formed from U2B, U2C, C1, and R5. A trimmer pot R9 allows us to adjust the sidetone level to a level suitable for our particular receiver.

From an external board (RF Detector Board), a DC signal representing transmit RF voltage level is applied to an analog comparator (U1A and supporting circuitry). This circuit compares that DC level (from the RF Detector) to the level set by R8, which is a portion of the reference level set by LED1 (used here like a 2 Volt zener diode). The comparator is capable of detecting milliwatt levels of RF, and upon detection, sends that signal to our OR gate U2D. In this way, we provide a level of protection for the receiver against inadvertant transmit power, and even energy coupled into the receive antenna when the receiver uses a separate antenna.

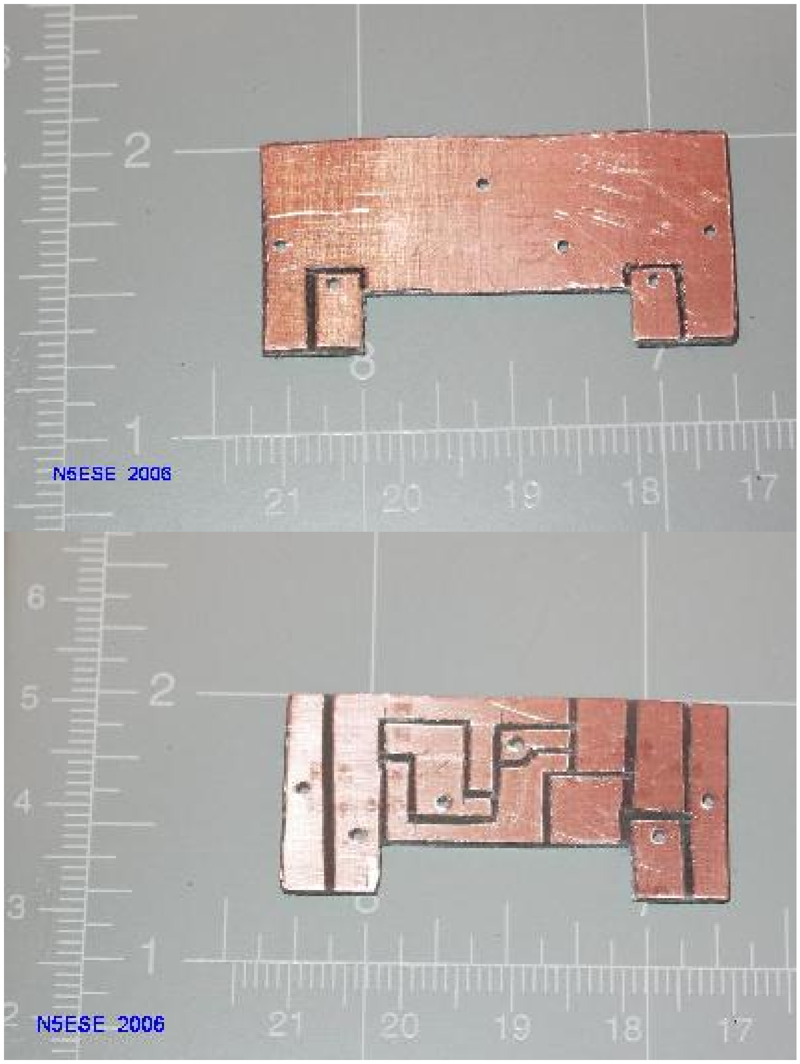
The total functionality is proviided on 3 boards (in this particular incarnation): A control board, the RF switch board, and an RF detector. This mainly reflects the evolution of the project, although there may be some design merit to removing the control circuitry from the vicinity of the RF Switch board and any circulaing ground currents that might exist there.

Below we see the RF Detector circuit, a small board placed in close proximity to the transmit antenna port. It functions like a classic RF Probe (diode detection method):



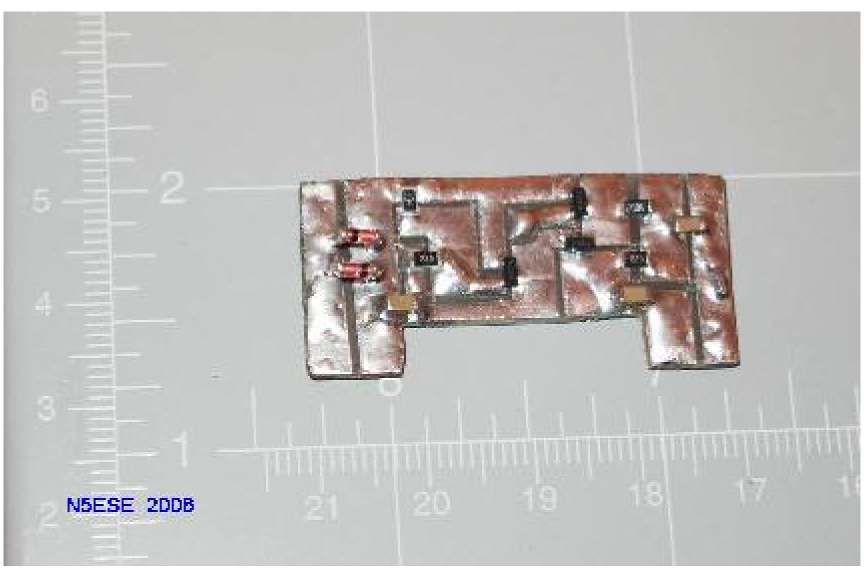
Construction

The Altoids tin provides the ideal compact, shielded assembly we need in this application. Unfortunately, using the prototyping methods chosen, we could not fit the 9 Volt battery inside, so that ends up "hangin' out". The two antenna connectors (BNC types) were mounted on one end of the box, and the RF Switch board was designed specifically to fit compactly between those two connectors, so as to minimize any stray RF fields or circulating ground currents that might introduce themselves into the control circuitry. The method also allows us to maximize OFF isolation and minimize ON resistance at RF frequencies. But to accomplish the small assembly, surface mount techniques were used ("cut-and-peel" fabrication methods). Here are some pictures of the RF Switch PCB, top and bottom, before mounting components:



(click on the above image to see a higher-res version)

And here's a picture of the RF Switch assembly, after mounting components, but before installing in the Altoids tin:



(click on the above image to see a higher-res version)

The RF Detector board was also built "surface mount" ugly style, on a small piece of scrap board. Control circuitry was built on a piece of scrap perf board. See the picture

below:

(click on the above image to see a higher-res, annotated version)

Hooking It Up

To hook it up, if the transmitter and receiver are to share one antenna:

1. Connect a "Tee" at the "TX-ANT" port of the T/R Switch
2. Connect a short piece of coax from the tee to the transmitter
3. Connect another short piece of coax to the antenna tuner (or 50-ohm antenna)
4. Connect a short piece of coax from the "RX-ANT" port of the T/R Switch, to the Receiver's antenna input jack.
5. Connect a shielded cable from the key (or keyer) to the KEY-IN port of the T/R switch
6. Connect a shielded cable from the KEY-OUT port of the T/R switch to the "key" input on the Transmitter (note: positive keying only, maximum 40V)
7. If a "ground-to-mute" input is available on the receiver, connect a short piece of shielded cable from that to the MUTE port of the T/R switch
8. If an "aux audio" (or "sidetone") input is available on the receiver, connect a short piece of shielded cable from that to the S/T port of the T/R switch
9. Assure 9-Volt power applied to the T/R Switch
10. Adjust your Antenna Tuner at low power (1 watt or less), or use a resistive bridge for tuning (or pre-tune the antenna)
11. Operate at will!

To hook it up, if using separate transmit and receive antennas:

1. Connect the transmitter to its antenna system as usual
2. Connect the receive antenna to the TX-ANT port on the T/R Switch
3. Connect a short piece of coax from the "RX-ANT" port of the T/R Switch, to the Receiver's antenna input jack.
4. Connect a shielded cable from the key (or keyer) to the KEY-IN port of the T/R switch
5. Connect a shielded cable from the KEY-OUT port of the T/R switch to the "key" input on the Transmitter (note: positive keying only, maximum 40V)
6. If a "ground-to-mute" input is available on the receiver, connect a short piece of shielded cable from that to the MUTE port of the T/R switch
7. If an "aux audio" (or "sidetone") input is available on the receiver, connect a short piece of shielded cable from that to the S/T port of the T/R switch

8. Assure 9-Volt power applied to the T/R Switch
9. Adjust your Antenna Tuner as you normally would
10. Operate at will!

Observations

I tested the circuit at 1W, 5W, and 10 Watts, using a K2 and external antenna tuner, pre-matched to 50-ohms. For the receiver, I used an old 70's vintage Heatkit HR-1680, which has both a mute and sidetone inputs.

80, 40, and 20 Meters performed flawlessly, and I made a few QSOs on 40M. On 15 and 20M, I began to see an affect on SWR, but it was still usable. When I removed the MUTE control, a significant amount of RF could be heard in the receiver (and observed on the S-Meter.

QSK (break-in) was in the neighborhood of 20-25 wpm, and receiver performance was not noticeably different than if it were hooked directly to the antenna. The RF detector was verified to protect the receiver, even if the transmitter was tuned without a key. Keying performance was as expected. With a separate antenna, the RF Switch isolation was sufficient even on the higher bands.

Subsequent tests on the bench revealed that the RF Switching was not providing the degree of isolation anticipated as a result of SPICE simulations. OFF isolation was seen to be about 18 dB at 30Mhz, increasing to about 36 dB at 4 Mhz. This leaves some considerable room for improvement, and I invite any suggestions. Still, the isolation is quite adequate for use on frequencies 14 MHz and lower, and still "usable" at the higher frequencies.

The 2N7000 switch has a maximum drain-source specification of 60V. While this corresponds to a transmitter power of 35 Watts in a 50-ohm antenna circuit, it only corresponds to a power of about 1-1/2 Watts for a 1000-ohm circuit. Therefore, the device is susceptible to catastrophic failure if it is connected to a badly mis-matched transmitter/antenna, even at QRP power levels. In using the T/R switch, then, it is wise to first adjust your antenna tuner for a good match at reduced power, and then raise the power to normal operating levels (but still no more than 10 watts). Alternatively, use an antenna tuner with a resistive bridge circuit, such as the Norcal BLT, because it provides a maximum mismatch of about 2:1 to the transmitter (when in the "Tune" mode).

As an added benefit, the T/R switch draws very little power in the quiescent (receive) state, meaning that the 9-Volt battery lasts a long, long time (I'm not sure how long, but I left mine connected for weeks at a time).

Conclusion

I think this is a useful gadget to have for anyone who likes to build QRP "separates". I'd heartily welcome suggestions that might result in improved performance, while retaining its "universal" application.

73, and enjoy!
Monty N5ESE

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N5ESE's Portable Solar Charger

(click on any picture to see larger version)
...more pix below...

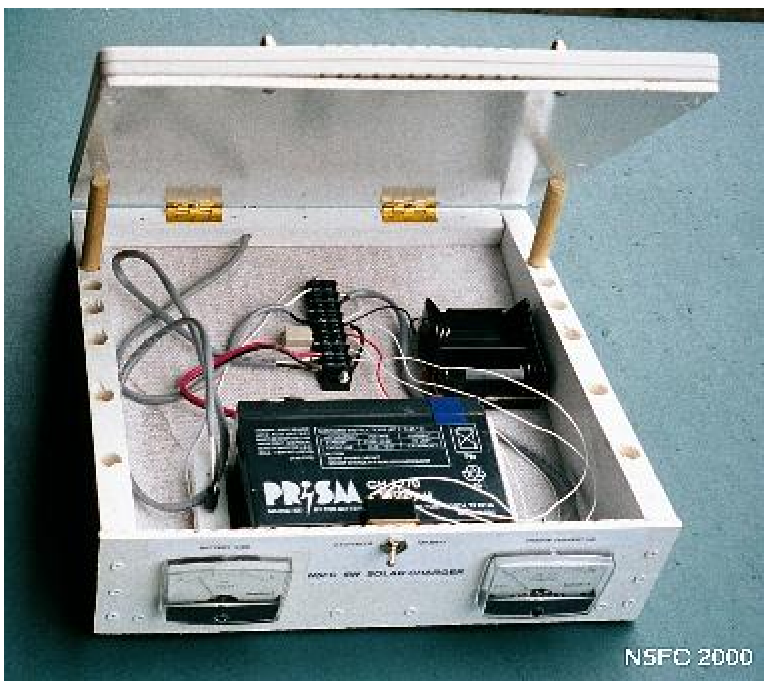
NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

Here's a neat little project that uses both your ham and carpentry homebrewing skills. (No jokes about my woodworking, now...)

About a year ago, I bought a 5 Watt solar panel on sale at Harbor Freight. It's an ICP Battery Saver Pro, and will supply about 15 Volts DC at 335 mA in full sunlight, which is about perfect for the 7 AH batteries I usually use for QRP portable. For a while, I just lashed-up some battery clips and wire, laid the solar panel on a lawn chair, and used a voltmeter to check the progress of the charging. I soon tired of hauling around all the piece-parts, and decided to consolidate battery, metering, and panel into a single enclosure. The result is what you see here, a 15" x 15" wood box about 5" high. This is not rocket-science, folks, so I'm not going to give dimensioned drawings, but I'll present the pictures with a description of what's going on, and you can duplicate it on your own from that point.

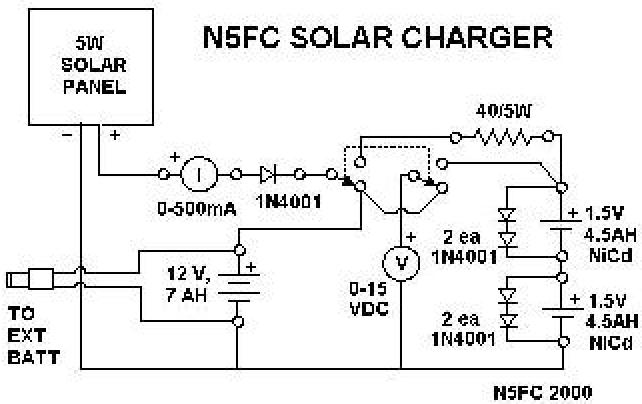
In the picture above, you can see what I'm trying to accomplish. I wanted to be able to store the battery and wiring inside the box, and hinge the top of the box so that it opens. The top of the box holds the solar panel, which can be propped at any convenient angle to maximize the solar collection (and so, the charging current). The box was built from 1x4" pine boards and 1/4" thick particle board. Cheap, real cheap...

The next picture (above) is a close-up of the method we use to prop the panel at the desired angle. I used two 1/2" dowels, about 3-1/2" long, one on each side of the solar panel. The sides of the box were then drilled at intervals, so that I could insert the dowels wherever I wanted along the side, to effect the desired angle. It works pretty well, and if I want the box closed (or near-flat), I just throw the two dowels inside the box, and the door-panel (solar-panel) serves as the top cover.



This image (above) shows the guts of the unit, and needs a little explanation. First, you'll see the 7AH, 12V battery. It connects with 1/4" quick-connect terminals, and can be swapped out readily (I keep 3 batteries standing by at all times). A little 1x1" wooden barrier keeps the battery from sliding around during transportation. Barrier strips were selected as tie-points for all wiring, in an attempt to keep things neat. Both current and voltage are monitored; current so I can verify charging is taking place, and voltage so I can see when to stop charging (around 14.4 volts maximum for a gell-cell lead-acid battery). I just used Radio Shack meters. I also installed a switch, and some circuitry for charging 2 NiCad D-Cells (the 4500 mAH type, which I use in my QRP battery booster accessory). The switch selects which battery is actively being charged (the lead-acid or the NiCad D-cells). This picture also clearly shows the hinges and holes for the propping dowels.

Here we see the front panel. The left meter reads the battery voltage, and the right reads charging current. The center switch selects which of the batteries is currently in the circuit. In this case, we see that the NiCad D-cells are in the circuit, that the voltage applied is about 2.5 volts, and the charging current is about 25 mA (from ambient indoor light)



Finally, here's a schematic of the electrical hook-up. The circuitry for charging batteries is unregulated, and depends on the operator to disconnect the battery before it gets overcharged. The circuitry for the NiCads is an especially crude regulator, but it keeps the batteries from over-charging. Here, two series silicon rectifiers limit the voltage to about 1.3- 1.4 Volts (1.43 Volts is about ideal for a NiCad to terminate charge), A planned improvement is to add real regulators so that over-charging cannot occur. A 14 Volt fixed-voltage-regulator would be ideal for the lead-acid battery, and maybe something a little more sophisticated for the NiCads.

Using this setup, I've found that I can charge a mostly-discharged 7-AH gell-cell in about 3 days of Texas sun. The NiCads take about 1-2 days.

Hope this gives y'all some ideas!

73, monty N5ESE

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N5ESE's QRP 0-35 Transmitting Inline Attenuator

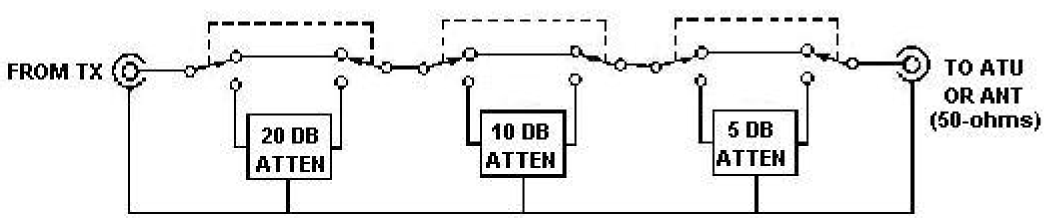
(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

If you have any interest in "milliwatting" (i.e., QRP ops below 1 watt), you're gonna **love** this project. Encouraged by our results on-the-air with the 10 db attenuator, we endeavored to expand our flexibility, with an attenuator switchable in 5 db steps from 0 through 35 db. Usable throughout the HF range (and maybe into VHF), it allows one to reduce a 5-watt signal in by about 1/3 with each 5db step, until you've divided it by 3000 (that's roughly 1.6 **milli**watts! Think you can't have some fun with that? You bet you can! Here's the clincher: cost: less than $25, and a couple of long evenings of your time.

We'll not go into all the details of attenuators in general. You might want to reveiew our other attenuator page for a more generic discussion.

Below is a schematic of the switchable attenuator. Click on the image to see an expanded image with a table of component values.

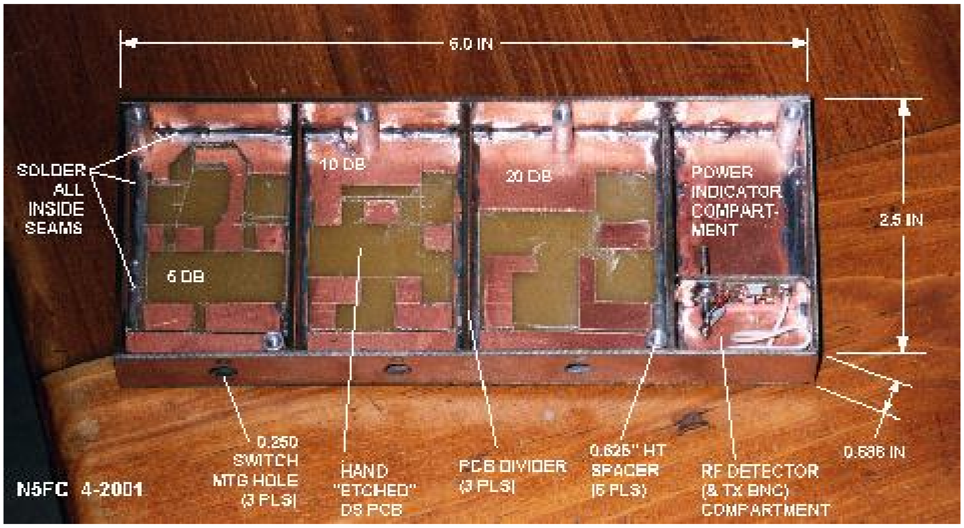


N5FC QRP SWITCHABLE 0-5-10-15-20-25-30-35 db Attenuator

Click on the image above to see a larger, more readable image and component data

We tried hard to make sure all the parts could be bought at Radio Shack. We ended up using their 1-watt 5% metal-oxide resistors (100 and 10-ohms), available there for a mere 25-cents each (RS 271-152). The remainder of resistors are common 1/2-watt carbon film, also available at Radio Shack. The DPDT micro-toggle switch (RS 275-626, $3) was selected for it's small form factor and it's excellent ratings. Two UG-1094 BNC jacks provide my favorite means of connecting RF.

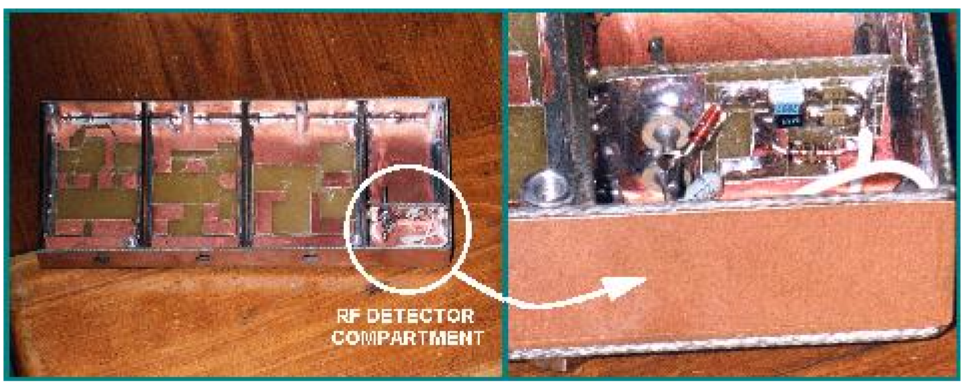
It's important to shield attenuators, especially when trying to achieve attenuation levels of 20 dB or more. We decided to use the tried-and-true method of building our own cabinet using double-sided printed-circuit board. Dividers of the same material provide compartments shielded from each other, with a single hole in each divider to allow the signal to pass from one section to another. Each piece is carefully cut, then soldered all along joining seams, creating an almost rf-tight box. After sanding the top side evenly against a sanding wheel (or using a block and sandpaper), a cover is fabricated from the same material. Six aluminum spacers determine the inside height of the assembly, and provide the means of mounting the cover. Here's a picture of the assembly before mounting components, with dimensions:



Click on the image above to see a larger, annotated image

Lands for soldering components were "etched" using a hobby knife **(WARNING! WEAR SAFETY GLASSES!)**, peeling away unused areas of copper.

If you looked carefully at the picture, you saw two extra compartments for optional equipment. A small divider near the input jack has components mounted (surface-mount-style) to provide an RF detector (RF-to-DC). The detected RF (now DC), is passed through the compartment wall via feed-thru-capacitors, for decoupling. Though it's not shown, the other compartment will contain circuitry for indicating the input power to the attenuator. The power indicator circuit contains window-comparators which drive one of three LEDs: less-than-2- watts, equal-to-5-watts, and greater-than 10-watts. This allows me to easily adjust my TX for 5 watts input to the attenuator. Here's a detail of the RF detector circuitry. (schematics of the RF Detector/ Power-Indicvator have not been posted yet, while I evaluate the performance and work out some bugs)



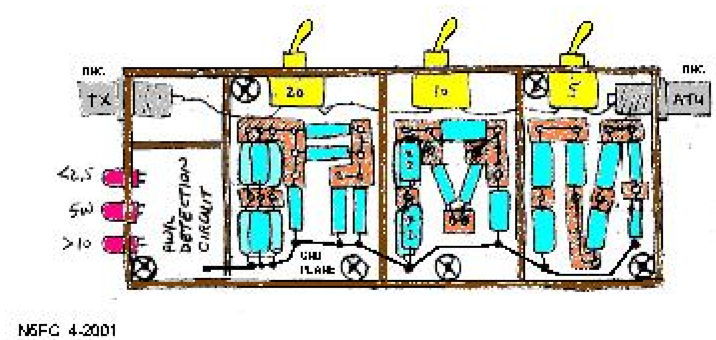
Click on the image above to see a larger, annotated image

Though the device is only sized to handle 5 watts, it may be used for up to 10 watts peak, for SSB or 50% keying. The RF Detector circuit and Power Indicator Circuitry is totally optional, of course, and may be omitted.

WARNING!

This device dissipates energy by generating heat. Heat generated in a small space translates to temperature rise, and temperatures can be hot enough (under the right circumstances) to burn people and ignite adjacent materials. Because of the thermal mass of the attenuator and its enclosure, that heat can stay around for a long time. Always locate your attenuator in a safe place, where there is no chance that it will burn people or catch something on fire.

Component layout and printed-circuit "etch" is as shown in the color-coded sketch below:

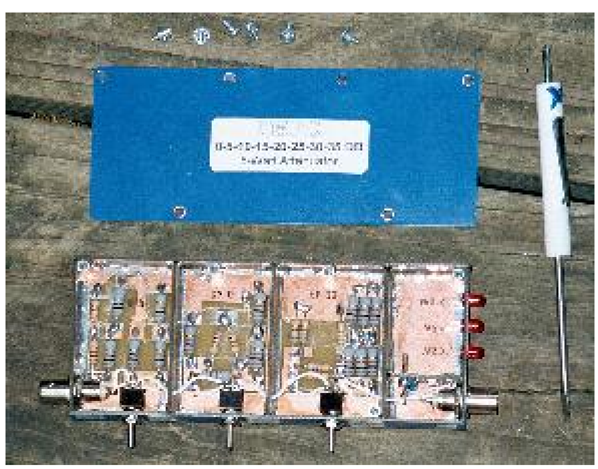


Click on the image above to see a larger, more readable image

Here's an actual photo of the completed assembly, viewed with the cover off (sans the Power-Indicator circuit):

Click on the image above to see a larger, annotated image

I elected to spiff up the unit with a coat of Krylon Blue, and lables generated on my PC. Here's an overall view with the cover removed:



Click on the image above to see a larger, annotated image

What kind of results did we get?

We measured the basic DC accuracy of the attenuator at all switch positions, with a 50-ohm load connected to the output:

SWITCH POSITION	INPUT R (OHMS)	ACTUAL (DB)
0 db	51.5	0 db
5 db	52.2	4.85 db
10 db	49.9	9.44 db
15 db	49.8	14.15 db
20 db	50.1	19.42 db
25 db	50.1	24.10 db
30 db	50.0	28.97 db
35 db	49.9	33.65 db

As can be seen, the basic accuracy of each attenuator section was within 1/2 db of nominal (about 10%), and within 1-1/2 dB with all three sections engaged. We wanted to verify the attenuation accuracy at RF, and I did the best I could with an RF probe:

SWITCH POSITION	40-METERS	20-METERS	10-METERS
5 db	4.68	4.74	5.04
10 db	9.45	9.40	9.55
20 db	18.75	18.33	18.97

I checked the input SWR in "Bypass" and all switch positions. At 30 MHz and below, SWR was 1.1:1 or less. At 146 MHz, it was as shown in the table below (Attenuation on 2 meters was not measured)

SWITCH POSITION	2-METER INPUT SWR (OBSERVED)
0	1.3 : 1
5	1.2: 1
10	1.55 : 1
15	1.6 : 1
20	1.9 : 1
25	1.8 : 1
30	1.8 : 1
35	1.9 : 1

I keyed-down at 5-watts input for 60 seconds. The unit barely got warm. Still, I recommend keeping the input power to 4-watts or less for continuous periods of 30-seconds or more, and not more than 8-watts at 50% duty-cycle (like with CW)

All this is useless fluff if you can't manage a QSO on the air. After testing, I fired up the Century 21, adjusted it for 5W output 20-meters (in the bypass position), and put in 30 dB of attenuation (for about 5 milliwatts out). After about 15 minutes, I happened upon Larry, W0QE in Denver, calling CQ. His signal was well over s9, so I knew I had a chance. I called, and we made a clean exchange. That's 767 miles, for over 150,000 miles-per-watt. Wow! Since he had solid copy, I asked to throw the last 5 db in, for roughly 1.6 mW, and he said he could still hear me in there, with about 75 % copy. Cool!

Can't wait to sail it on 10-Meters with a little solar wind to help ;-)

73, and enjoy! monty N5ESE

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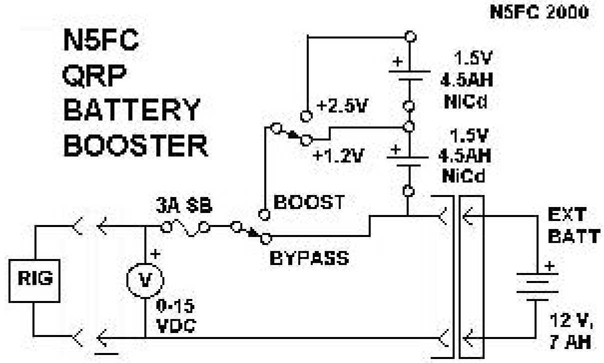
N5ESE's QRP Battery Booster

(click on any picture to see larger version)
...more pix below...

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

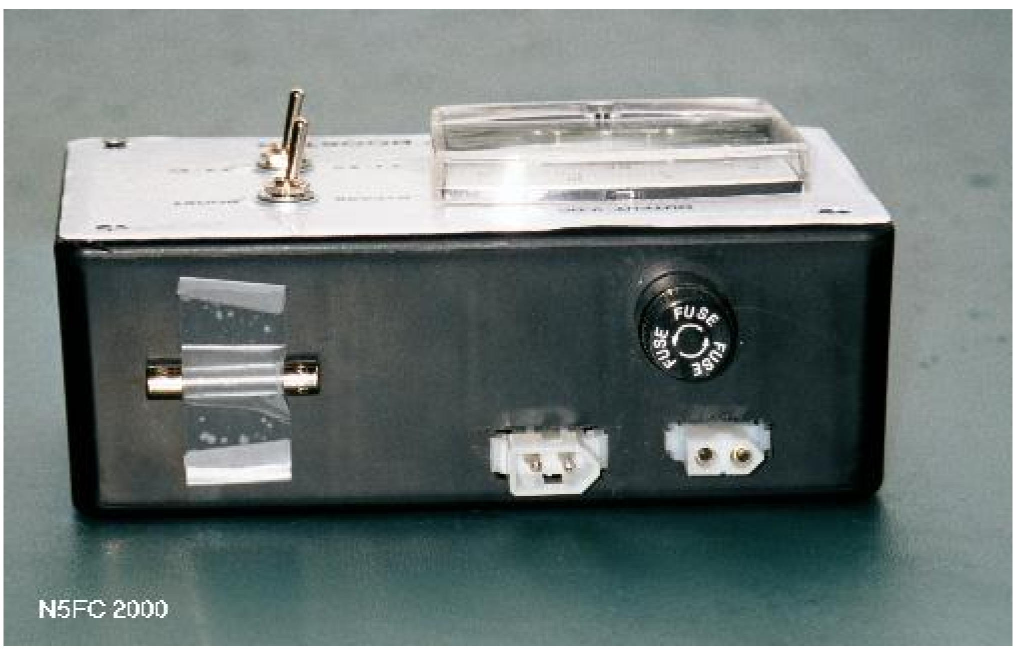
Everybody that runs QRP with solid state rigs knows some of the potential problems that result when the battery you're using begins to lose it's charge. Most gear is designed (and specified) to run at 13.8 Volts. Power Output in non-ALC-controlled rigs is proportional to the square of the applied voltage. Even on a fully-charged lead-acid (gel-cell) battery, the loaded voltage will quickly fall to 12.5 V, and the output power will only be 80% of it's rated value. As the battery reaches about 1/2 of its rated capacity, voltage will drop to around 11 Volts, resulting in about 2/3 rated power. In many QRP rigs (including my Ten-Tec Scout), malfunctions or other performance problems occur below 12 Volts. To complicate matters, the cable between the rig and the battery may provide additional voltage drops, especially during transmit. For example, a 5-Watt QRP transmitter that uses 1 Amp of current during transmit, may lose an additional 0.1 to 0.5 Volts through a typical portable battery connection and cabling (most loss in the connectors).

The QRP Battery Booster here is an attempt to circumvent these problems. It was designed to be small, light, and portable, and work in conjunction with a 12 Volt battery for field day or portable operation. The idea is simple: when the 12 volt battery drops by 1.2 Volts, add a battery with similiar capacity and current-capability *in series* with the main battery, bringing the rig's operating voltage back up to nominal (or close to it). Here's a schematic:

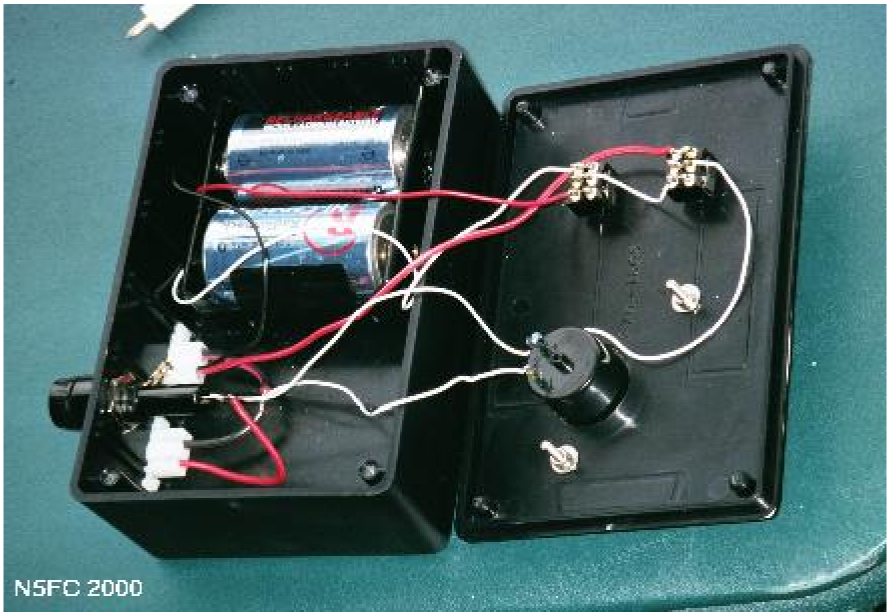


To implement this, we procured a plastic project box from Radio Shack (RS 270-1806), which is large enough to hold 2 D-cells and their holder, with enough panel space to mount a panel-mounted voltmeter and two toggle switches. We'll arrange the circuitry so that we can switch in either one or two NiCad cells (although you could use Alkaline cells if the load current is not too high). A second switch will allow us to bypass the battery booster so that we don't have to physically remove it from the battery circuit. A picture of the front panel is shown at the very top (click on the image to see a larger version). Front panel labels were created using sticky-back paper (Avery 8-1/2 x 11 mail labels) and the trusty ol' PC & printer.

The 12-Volt battery input/output connectors are the ARES-recommended (Molex) connectors, panel-mounted using the connectors' integral mounting ears. The project box is pretty soft plastic, and it was easy to drill a rectangular pattern for the Molex connectors, then shape it out with a hobby knife (Wear Eye Protection!). My sloppy results are shown in the picture below. Notice also the fuse, which is intended to protect against short-circuiting the main battery.



The picture below shows the inside layout and wiring, which is completely non-critical. If you use battery-holders molded out of thermoplastics, I recommend getting two one-cell holders, with wires already attached, because the thermoplastics do not hold up well (at all) to soldering operations.



Operation is very simple. We assume you've installed two freshly-charged NiCad D-Cells. We prefer the 4500 mAH type (RS 23-140) even though they're very expensive, because they have about 3-times the capacity of standard cells, and have current sourcing capability similar to the main battery we'll be using. Connect the source battery (I use a 7AH, 12V gel-cell) to the input jack. Connect your QRP rig to the output jack. With the switch in "BYPASS" begin operation. Check the front-panel voltmeter from time to time, and when it drops below 12.5 Volts, switch in the first D-Cell "+1.2V". Wow! Back to full power! When it again drops below 12.5 Volts, switch it to both D-Cells "+2.5V". Again, back to full power! This is a really neat way to maximize your battery-operating capabilities.

When using this setup with my Ten-Tec 1340 (a 3-watt QRP rig) during Field Day '99, I operated for 21 hours, switched in the first D-cell after about 4 hours, and never got past the first D-Cell. Cool!

73, monty N5ESE

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N5ESE's QRP Dummy Load

(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

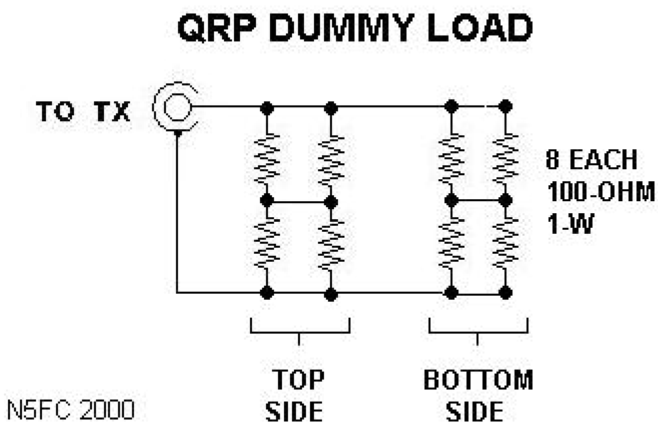
This is another variation on the "parallel resistor" dummy load. [Go -here- for a discussion on dummy load theory]. This is one I built during my infatuation with copper pipe. It's perfect for QRP HF operation of 5-watts or less average power, and should be adequate for continuous operation at that level. It's light and compact, about 2-1/2" in length overall.

WARNING!

Dummy loads dissipate energy by generating heat. Heat generated in a small space translates to temperature rise, and temperatures can be hot enough (under the right circumstances) to burn people and ignite adjacent materials. Because of the thermal mass of the dummy load and its enclosure, that heat can stay around for a long time. Always locate your dummy load in a safe place, where there is no chance that it will burn people or catch something on fire.

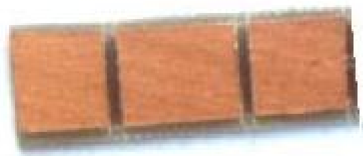
The 1/2" copper pipe provides a convenient, compact form factor, is an excellent shield, and helps to dissipate heat to the outside world. Copper end-caps, available at most any hardware or plumbing supplier, provide a means of mounting the UG-1094 BNC jack and closing the unit.

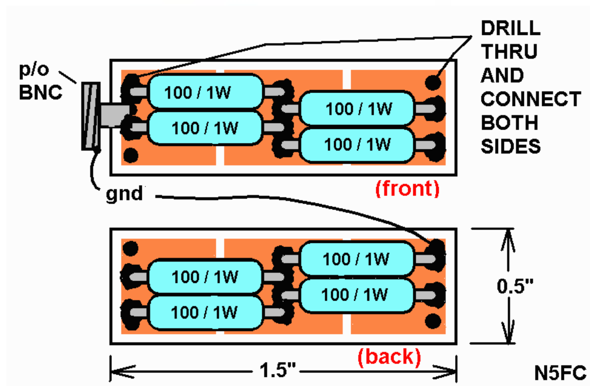
This version uses 8 each 100-ohm 1-watt 5% metal-oxide resistors. Available from Radio Shack for a mere 25-cents each (RS 271-152), you'll invest all of $2 for the parts. The resistors are good through the HF range, but don't do particularly well at VHF. Here's a schematic:



We'll fabricate a printed-circuyit board from scrap double-sided copper board, cut to 1/2 x 1-1/2-inches, and grooved to form 3 pads on each side. On the top side, we'll mount 4 of the 8 resistors, and on the bottom side we mount the remainder. Simply tack-solder the resistors to the board. At the pads on the ends, we drill a small hole through the board, and solder a wire in place top-to-bottom. On the top side, we end up with a 100-ohm, 4-watt equivalent resistor (a pair of parallel 100 ohm resistors makes 50 ohms, and two pairs in series make 100-ohms). When we join the top and bottom in parallel, our equivalent resistance is 50-ohms (two 100-ohm quads in parallel).

Here's a sketch of the pc-board layout:





(click on the above picture to see larger version)

Mount the UG-1094 BNC Jack in one of the copper end-caps. then, connect the pc board assembly directly to the center post of the BNC connector, soldering same. Connect the far end of the board to the BNC ground post, via a short piece of bare wire. Wrap the entire pc board assembly liberally with plumber's teflon tape (available for a buck in the plumbing section of any hardware store). Then run the bare wire outside the teflon tape. DO NOT use other types of tape (they *will* melt!). Next, we slide a short piece of 1/2-inch copper tubing over the assembly, slipping it into the BNC/end-cap. At this point, an ohmmeter should verify 50-ohms. Finally, mount the other end-cap to close and shield the unit. Drill and tap a screw into both end caps to connect the shield both electrically and mechanically.

When supplied RF power for an extended time, this dummy load can get quite warm, even with just 5 watts. Be aware, and plan for it. (Read the "WARNING!" above). My version has an SWR of 1:1 throughout the HF range (DC to 30 MHz). Another variation of this, that includes an rf detector for measuring power, can be viewed -here-.

73,
monty N5ESE

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N5ESE's QRP Open-Wire/Twinlead Antenna Switch

(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

This is one of the most all-around useful projects I've built. It came about when I decided I needed more than the single 40-meter vee. I threw up some other antennas, tested them, and decided I'd like to keep them all around. I prefer balanced antennas that use open-wire feedline along with my trusty antenna match. It quickly got real tedious to swap out open-wire feeders on the rear of the antenna tuner every time I switched to another band. There *had* to be a better way!. I perused the internet and ham catalogs for a commercial antenna switch that would handle open wire feeders. I found lots of coaxial switches, but no open-wire or twinlead types... not one! Amazing! Am I the only one using open-wire feeders? (I don't think so)

This project grew out of the need for a convenient way to switch open-wire fed antennas. Intended for QRP levels only (10 Watts PeP and below), it provides for selecting any of three antennas to go to either (or both) of two antenna tuners/transceivers. Let me expound on that a little. Using three toggle switches, you can attach any one of the three antennas to Tuner "A", and any one of the other unconnected two antennas to Tuner "B" - and at the same time. You can also disconnect any or all of the antennas, leaving them floating. When floating (unconnected), resistors on each open-wire line to ground provide for static dissipation caused by wind. Two more toggle switches allow the antennas to pass through to the antenna tuners, or to be disconnected from the antenna tuners and grounded to earth. To enhance my version (but certainly optional for the builder), I added gas discharge tubes across the selected antenna, to provide at least a modicum of protection to the receiver front end. Cost? About $20 (not counting the gas-discharge tubes and wire, which I scrounged)

WARNING!!

All antennas and antenna switching units carry some risk of personal injury or property damage, for several reasons. Here are some of the risks associated with this unit. The list is not intended to be all inclusive. Build and operate at your own risk. I am not a licensed Antenna or RF or Electrical Engineer. Here's the scoop: All antennas (and especially balanced ungrounded antennas) pick up much more than simply the desired RF energy. Wind, rain, and severe weather, even if not in the immediate vicinity, can build static (and not-so-static) charges that can find their way down the feedline. If these charges have enough energy or enough energy gradient, they can damage equipment, start fires, or injure (and even kill) people. If you do not understand the ways this can happen, DON'T BUILD THIS UNIT, AND DON"T PUT UP AN ANTENNA! *Educate yourself*, and minimize the risk! You owe it to yourself, your family, your neighbors, and the amateur radio community. Such charges, when they reach a threshold level, find a path to earth ground one way or the other. Sometimes, that path is not what you anticipate it to be. Such energy may decide to exit to ground through the insulation of the feedline, across an open switch contact, through the front end preamp or final of your transceiver, through your window sill, wall board, or furniture, or through your body if you happen to be close enough at the wrong moment in

time. Don't presume you know how it's going to happen; BE SAFE FIRST, so you won't have to be sorry. In this unit, the grounding wires are relatively small (AWG 18) and could fuse if a lot of current runs through them. They also have a fair amount of self inductance, which can lead to large voltages if the charge is able to develop large di/dt's. To obtain what protection *is* afforded, the unit ground MUST be connected to a good earth ground. Also, this unit is not intended to operate with powers greater than 10 Watts PeP. To do so could stress the components, cause spurious emissions, and possibly cause the unit to catch fire.

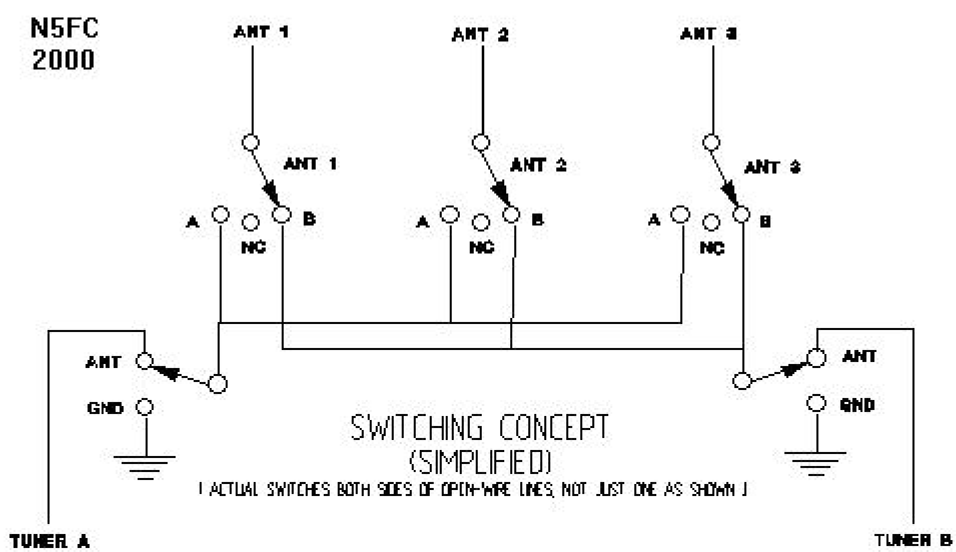
The Switching Concept

The switching concept can be seen in simplified form in the image below. Keep in mind that only one side of each feedline is shown in the simplified schematic. As you can see , each antenna's feedline, arrives at its own antenna switch and can be directed in one of three ways, via the double-throw-center-off switch:

- connect to the "A" tuner's switch
- don't connect at all (i.e., float)
- connect to the "B" tuner's switch

Once selected to go to the "A" or "B" tuner's switch, the double-throw "A" or "B" switch may then be thrown into either of two positions:

- ground the antenna
- connect the antenna to the selected tuner



Click on the image above to see a larger, more readable image
And look -here- for a complete wiring diagram

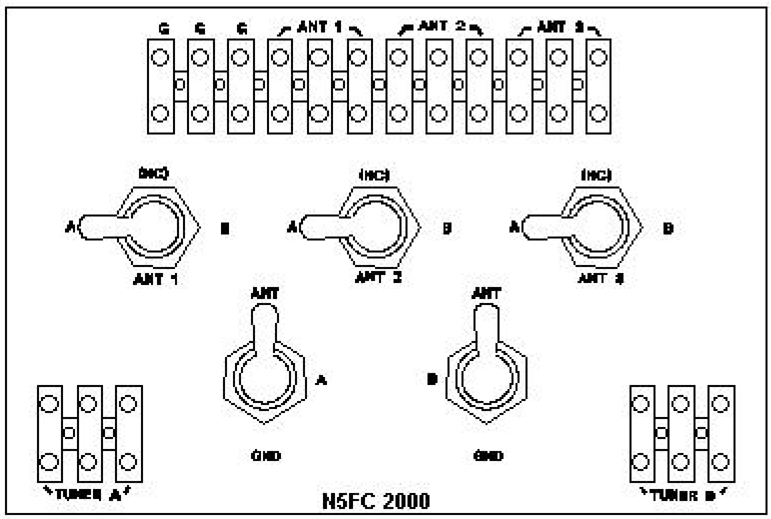
It's also very handy, when not using some or all of the antennas, to connect all the unused antennas to the the tuner not currently being used, and throw the tuner switch to "ground". When I walk away from the transceiver after an operating session, I make sure all the antennas are grounded. It only involves throwing a couple of switches. And as long as the weather's not severe, I don't worry too much about having one of the antennas disconnected. 1 Meg resistors placed from each feedline to ground bleed off slow static buildup caused by moderate wind, rain, and antenna movement. They are sized to cause less than 1% RF losses under most matching conditions.

In my version, I added gas-discharge tunes across the feedline to each tuner switch, and from each feedline to ground. I scrounged these gas discharge tubes from old commercial modems, but you can buy them for around $8-12 each. I think they're worth it, for those times when I'm away from home, and I've forgotten to ground my antenna (Hey, it happens...) Rated at 280V, they are a reasonable compromise between protection and operation

without distortion. In a 1000-ohm antenna circuit, they should allow about 78 Watts Peak before limiting, and at 5000-ohms, 16 Watts Peak. This is well above the operating specification of 10 Watts-PeP.

Construction

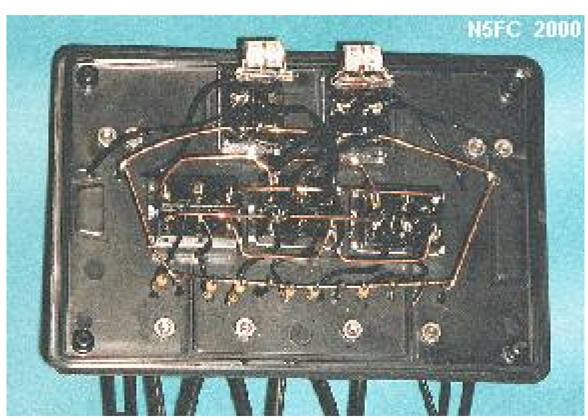
I built my antenna switch in a compact Radio Shack project box, approximately 6 x 4 x 2 inches, and used heavy-duty 60-Hz AC rated toggle switches with large bat-handles. The project box is really easy to drill, and comes with a choice of metal or plastic panel. We used our PC to print lables on sticky-backed paper (obtainable from any office-supply store), which we then applied to the front and side panels. You can see a photo of the front panel at the top of this page. Here's a layout sketch of the main panel:



Click on the image above to see a larger, more readable image

Click -HERE- for a complete wiring diagram, annotating component part numbers, and showing both sides of the feedlines. [Make sure your browser's page or printer-setup is set for "landscape" mode to assure best printing]

I used AWG 18 solid bus wire inside the unit, and arranged it to minimize losses and minimize disturbing the natural SWR of the feedline. I have not actually measured losses. Likewise, grounds are arranged to minimize inductance. The barrier strips are of the "euro" variety, because they don't require you to prepare the mating wire (other than to strip it about 1/4 inch). A wire is fed from one side of the barrier-strip terminal through a 1/16-inch hole in the project box, to the inside, where it is routed to its connection point. Here's an image of the internal layout:



Click on the image above to see a larger, annotated image

Installation

I mounted my antenna switch upside-down under the first shelf at my operating station, as shown (and circled) in the image below. This is a very convenient place for me to swithch antennas when band-hopping or antenna comparing.

Click on the image above to see a larger image with more detail

And here's a close-up of my (operating) view of the antenna switch:

Click on the image above to see a larger image with more detail

The QRP Open-Wire/Twinlead Antenna Switch is a great time-saver really easy to use, and I think you're going to like it a lot.

Enjoy! and 73!
monty N5ESE

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N5ESE's QRP Transmitting Inline Attenuator

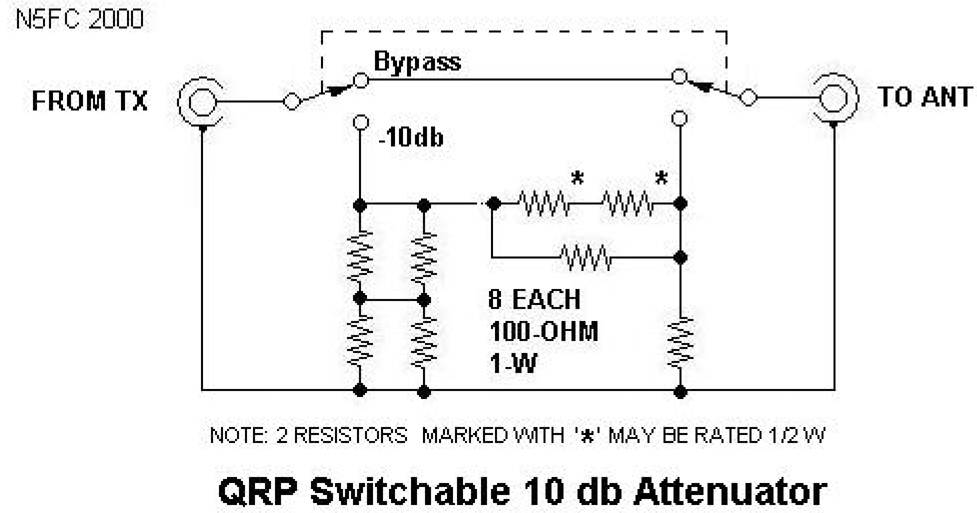
(click on any picture to see larger version)

NOTE: 'N5ESE' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

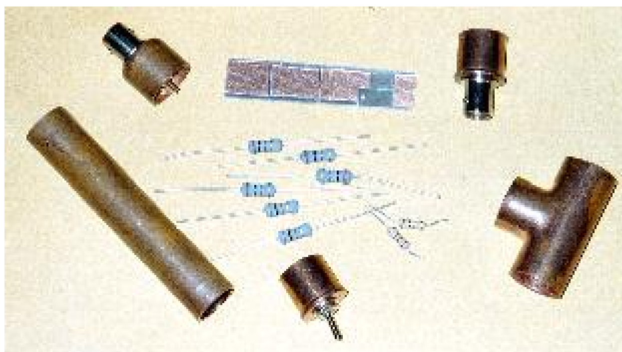
Any QRPer knows how much fun operating with low power can be. A decrease of power from 50 watts to 5 watts is -10 db, or about 2 S-units. The increase in fun is about an order of magnitude, too. Usually, decreasing power to a tenth of normal power can be effected simply by turning the transmitter's drive control down, if you have a commercial rig. But there's a point of diminishing returns, and it's frequently impossible to lower the power much less than a few watts, and even harder to know what that level is. With simple QRP rigs, the drive is often fixed, and the power thereby set to 2 - 5 watts. Wouldn't it be great to have the means to readily and easily decrease that QRP power by a factor of ten, thus making QRP even more fun? And for about 5 or 6 bucks?

Well, that's the basis for this project, a *switchable* 10dB transmitting inline attenuator. Simply place this device inline between your transmitter and antenna tuner (or other 50-ohm load). With the switch in the "BYPASS" position, full power goes to your antenna normally. A flip of the mini-toggle switch to "-10 db", and your output goes to one-tenth of its original power. In either position (assuming your antenna tuner is properly adjusted with high-power applied), your transmitter sees 50-ohms.

Below is a schematic of the switchable attenuator. We used 8 each 100-ohm 1-watt 5% metal-oxide resistors, available from Radio Shack for a mere 25-cents each (RS 271-152). The DPDT micro-toggle switch (RS 275-626, $3) was selected for it's small form factor and it's excellent ratings. Two UG-1094 BNC jacks provide my favorite means of connecting RF.



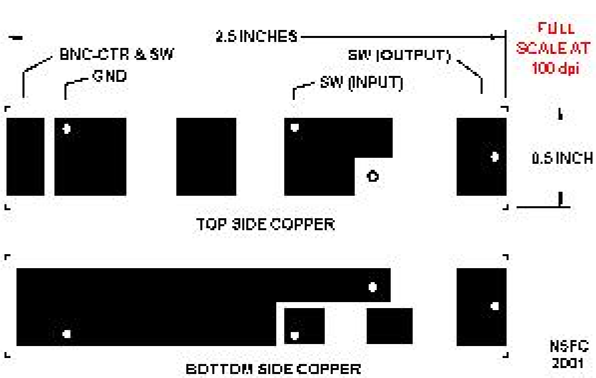
We're not talking a lot of parts... here's a picture of the parts gathered just prior to assembly:

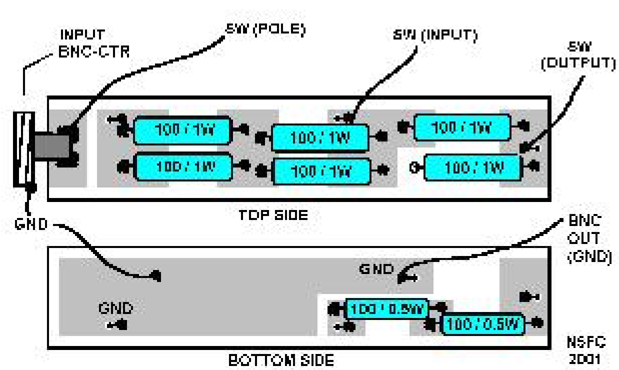


Click on the image above to see a larger, more readable image

If you do the math, you'll discover that the attenuator isn't really 10 db (it's 9.6). This means that for 5 watts input, you'll get about 550 mW out (rather than 500 mW). The compromise is miniscule, and allowed us to use equal-value, off-the-shelf resistors. The input/output impedance is still within 5% of 50-ohms, so it should provide low SWR operation throughout the HF range.

We mounted the resistors on a piece of scrap double-sided printed-circuit board, about 2.5 x 0.5 inches. Using a hobby knife (and SAFETY GLASSES!!!), we formed pads on both the top and bottom of the pc board. All resistors and wires were then tack-soldered to the pc board. Sorry, but you'll have to use teflon-coated wire for the wiring, because the resistors can get very hot in this application. Here's a sketch of the pc board copper and component layout:





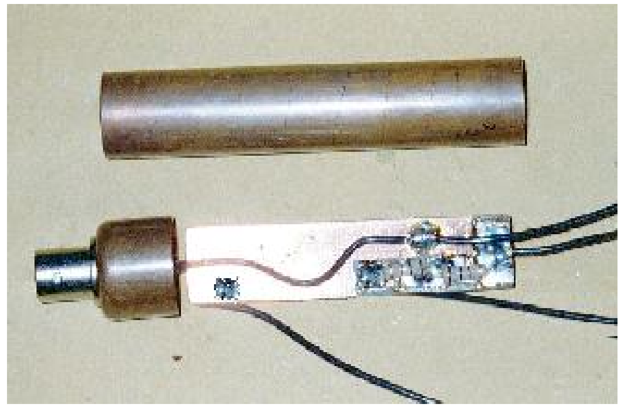
Click on either of the above images to see a larger, more readable image

Note that where holes are drilled through the board, a wire provides continuity from top to bottom (solder on both sides)... otherwise, everything is soldered "surface-mount" style, with a big blob of solder holding the

components down (don't get carried away). The center pin of the input BNC connector gets soldered directly to the foil where shown.

As you can see, I was still on my copper-pipe-kick when I built this attenuator. You may, of course, elect for some other packaging, though at 5-1/2" long, this unit is very compact and portable. The 1/2" copper pipe provides a convenient, compact form factor, is an excellent shield, and helps to dissipate heat to the outside world. Copper end-caps, available at most any hardware or plumbing supplier, provide a means of mounting the two UG-1094 BNC jacks and toggle switch, and closing the unit.

Here's a picture of the front and back-side board assembly just prior to putting it inside the copper tube:



Click on either image above to see a larger, more readable image

Wrap the entire pc board assembly in plumber's teflon tape before installing it in the copper pipe, to prevent shorts. DONT be tempted to use any other kind of tape (because of the spot temperatures involved)

WARNING!

This device dissipates energy by generating heat. Heat generated in a small space translates to temperature rise, and temperatures can be hot enough (under the right circumstances) to burn people and ignite adjacent materials. Because of the thermal mass of the attenuator and its enclosure, that heat can stay around for a long time. Always locate your attenuator in a safe place, where there is no chance that it will burn people or catch something on fire.

Check you wiring before applying power to this attenuator. Check that the "BYPASS" position shows 0-ohms continuity from input center-pin to output center-pin, and no continuity from center-pin to ground. Then, with the switch in the "-10 db" position, verify 60-65 ohms at the input (center-pin-to-shell) and the same at the output. Then, measure from input-center-pin to output-center-pin and verify 50 ohms (approximate).

How does it work?

I checked the input SWR in both the "Bypass" and "-10 db" switch positions. At 30 MHz and below, SWR was 1.1:1 or less. At 146 MHz, it was 1.3:1 in "bypass", and 1.6:1 at "-10 db". Attenuation on all HF bands was measured at 9.6 to 9.65 db. (Attenuation on 2 meters was not measured)

I keyed-down at 5-watts input for 60 seconds. The unit barely got warm. Still, I recommend keeping the input power to 4-watts or less for continuous periods of 30-seconds or more, and not more than 8-watts at 50% duty-cycle (like with CW)

The fun really starts when you put this thing on the air. As soon as I got it buttoned up, I started cruising 40 meters around the QRP calling frequency for a CQ. I didn't have to wait long before I heard Lionel K6CEQ, and gave him a call with the attenuator "IN", i.e., 1/2-watt output. He came back to me with his QRP 5-watts and a 559 report. We made a couple of solid exchanges at that power level, at which point I switched to "Bypass",

gained a couple of S-units, and finished out our ragchew. Austin, TX to San Diego, about 1155 miles, and about 2300 miles-per-watt. Not Bad!

When the band is really hot, and I'm using the TenTec Century 21 (which allows you to adjust the drive level), I adjust it for 5 watts out with the attenuator bypassed. Then, I switch in the 10 db attenuator, and note the exact position of the forward power needle on my SWR Meter. Next, with the attenuator bypassed, I readjust the drive level to match that mark (i.e., 0.5 watts instead of 5 watts). Now, with the attenuator "IN", I'm transmitting 50 milliwatts, and with the attenuator in "bypass", 500 mW. Using this technique, I was able to call and exchange info with Jim, AL7FS, in Achorage, Alaska, using only 50 mW of power, a path of 3144 miles for 62,880 miles-per-watt!

For those worried about the attenuator being inline during receive, I have not found this to be a problem, as my TenTec Scout has plenty of reserve gain for the bands I work. On the DX bands, you may elect to switch to bypass during receive cycles.

Here's an idea: build two of these and work super-QRP!

73, and enjoy! monty N5ESE

Here are more pictures of this attenuator:

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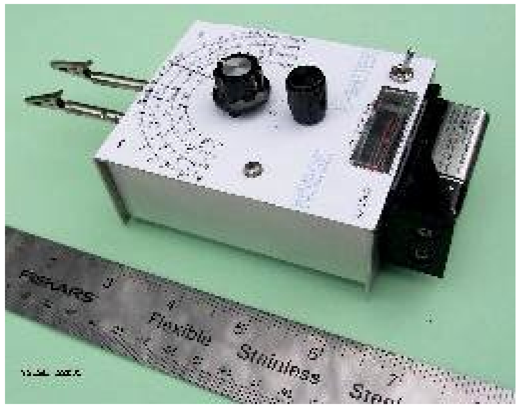
N5ESE's RF Inductance Meter



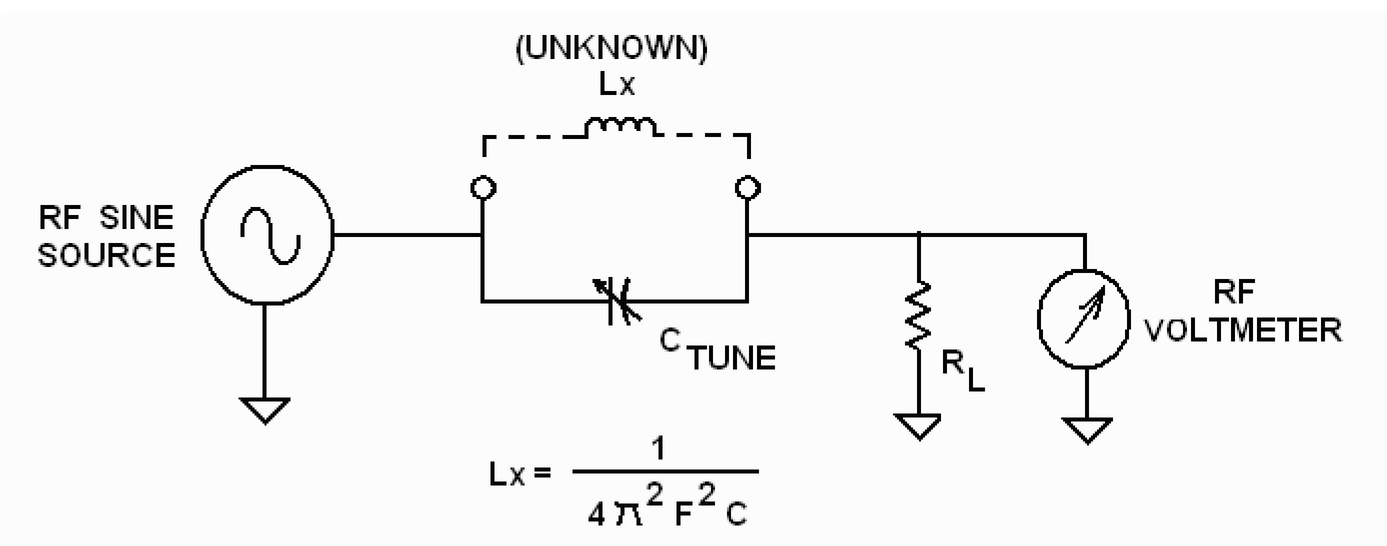
(click on any picture to see larger version)

I'm always looking for cheap and simple ways to accomplish tricky tasks. As an RF homebrewer, I frequently wish I had a way to reliably measure inductors I wind for projects. Most of my homebrew projects are in the HF range, that is, 3- 30 MHz. Most commercial inductance meters, however, use low frequencies (less than 100 KHz) to measure unknown inductances. This is probably adequate for air-wound coils, but as many have found out the hard way, not too accurate for toroidal-wound or slug-tuned inductors designed for RF. The effective permeability of these core materials are optimized for RF frequencies, and don't respond the same when low frequencies are applied to them.

Presented here is a "Saturday" project I built from parts already in my junk box. Had I bought them all new, I estimate the cost would have been less than $35. The L-Meter here measures inductors in the range 0.15 thru 65 uH, and uses signal sources in the HF range that are suitable for measuring toroidal or slug-tuned inductors generally found in ham radio circuitry in the 80 - 2 meter range (as well as air-wound or form-wound inductors). It will **not** measure audio or IF inductors, but I find that those are not the ones I'm usually trying to measure, nor are they the ones that usually cause me problems.

Theory

There are many clever methods that have been devised to measure inductance and capacitance, but I wanted to go back to a tried-and-proven traditional method, and put a new twist on it. Here's a block-illustration of what we'll try to do:



Recall that when an inductor and capacitor are placed in parallel, they form a resonant "tank" circuit, in which the impedance (resistance) across the circuit becomes very large at the resonant frequency. This means that relatively little AC current will flow through the circuit at resonance. As the frequency moves off-resonance, however, either the capacitor or the inductor tend to allow AC currents to flow around the circuit. If the frequency is above resonance, the capacitor is the culprit, and if below, the inductor. We'll exploit this property to design a simple L-Meter (Inductance Meter).

Referring to the block diagram above, lets imagine that we apply a single frequency sinusoidal source (left) to a series circuit consisting of a parallel tank circuit (C-TUNE, our tuning capacitor, and Lx, our unknown inductor) and a light resistive load (R-L). If we have a fancy-dancy RF Voltmeter (a good Oscilloscope would be a great way RF Voltmeter), we would measure the voltage at the load resistor (R-L). Most of the time, the voltage would be fairly steady, something less than the applied voltage from our source, but not a whole lot less. Provided that we have enough range on our variable capacitor to resonate with Lx, as we tuned our capacitor from one end to the other (i.e., maximum to minimum, or vice versa), we would notice that there is one unique capacitance setting where the voltage across the load resistor drops way, way down low. If our RF Voltmeter were a true meter, rather than an oscilloscope, we would see a pronounced "dip" of the pointer as we passed through resonance. By the way, if we never saw a dip, it would probably be because our inductance is too small or too large to resonate with the range of capacitances our tuning capacitor provides.

If we knew exactly what capacitance we had when we reach the lowest "dip", we could use the formula shown to calculate the unknown inductance. We would simply plug the frequency (in Hz), and that exact capacitance into the formula, do our calculation, and presto!... we know our inductance. Here's an example: let's say we have a source generator of 5 Volts peak-to-peak at a frequency of exactly 10 MHz. Lets say our tuning capacitor (including stray capacitances, you sly dawg) will vary from 25 to 225 pF. We watch our RF Voltmeter, which seems to read in the neighborhood of 2.5 Volts when we have our tuning capacitor at minimum. We slowly turn our tuning capacitor, while watching the meter, and about midway we see the voltage dip way down to almost nothing. We set the tuning capacitor right there, where the dip is deepest. Our dial tells us that the capacitance is 120 pF. Now we have enough information to calculate our unknown inductance:

```
L = 1 / ( 4 * PI * PI * 10,000,000 * 10,000,000 * 0.000000000120)

  = 1 / (4 * 3.1416 * 3.1416 * 10E06 * 10E06 * 120E-12)   [calculator notation]

  = 2.11E-06 [calculator notation]

  = 2.11 uH (microhenries)
```

We could take it one step further to figure out the range of unknown inductances we could measure, because we know the minimum tuning capacitance is 25 pF, and the maximum is 225 pF. Plugging those two numbers (min and max C, separately) into the equation, we come up with a range of roughly 1.1 - 10 uH.

That's a fairly useful range for RF homebrewing on 40-20 Meters, but we'd like a little bit more and a little bit less, for the lower and the higher bands. One thing we could do is switch to half-frequency (5 MHz) or double-frequency (20 MHz), while keeping the same capacitor. When we do that, we come up with a Lx range of 4.5 - 40 uH, and 0.3 - 2.5 uH, respectively, or a total measuring range of 0.3 - 40 uH. Now, that's useful!

OK, But What 's the "Gotcha" ?

There are always "gothchas", but they're fairly minor in this case.:

1. I don't want to dedicate my signal generator to this task
2. I don't have an RF Voltmeter nor an oscilloscope
3. I want to use parts in my junkbox, if possible
4. And the "Biggee": I don't know the capacitance on my tuning capacitor at every point along the dial

Let's dismiss the first three challenges in short order:

We'll use el-cheapo CMOS/TTL crystal-controlled clock generators as sources. I'm talking about the type that are used to drive microprocessors, and which are made by the gazillons so that they are dirt cheap (like, less than $4 each). Turns out the frequencies we've already talked about are standard manufacture, so they're cheap and readily available. But wait, you say! Those clock modules have square-wave output. Not to worry, we'll add an R-C filter at the output of each clock, to reduce the harmonics enough that we'll get no false dips. That's all it will take... one 5-cent resistor and one 10-cent capacitor. That will reduce our output slightly, but there is plenty enough output capability in the clock chips to take care of our needs, even with the extra filtering. Of course, we'll need to select the values judiciously, to accomplish the correct filtering action, but even that is plus-or-minus 20%, so no big deal at all.

We'll use one of the cheapest, most reliable RF Voltmeters known to technology - the diode detector. Talk about simple - two germanium diodes - 10-cents apiece plus a cheapy DC micro-ammeter. If you don't already have the meter in your junkbox, buy one from a surplus/electronic clearance house, or steal one from a cheap junk voltmeter... I think we can live with the shame.

Please DO use parts in your junkbox. I pulled the clock modules I used out of old castaway modems. They've been sitting in the j-box for years, waiting to be used. Use whatever variable capacitor you have. I used some polyvaricons I bought years ago from someone on the QRP-L mail-list. They had one shaft but two sections, and were very tiny, about 1in x 1in x 0.5in. I paralleled the sections to come up with the range we talked about. You could scrounge from an old table or pocket AM/FM receiver, or use that swapfest variable cap you couldn't resist buying 10 years ago. (I've been there, too, compadre). I used a 0-250 microamp edgewise meter I bought from Dan's Small Parts. Originally, the scale was intended to read S-units (probably for a Chicken-Band radio). Scale makes no difference at all here, because we're only looking for a "dip" in the reading. Probably, any panel meter with a sensitivity of 0-1 mA or less will work just fine.

Ah, yes, the "Biggee". How do I know what the actual capacitance of my tuning capacitor is? This is the biggest challenge of the project, but it's really not that big. You could use the exact same capacitor I did (a polycon variable with two sections, nominally 60 and 160 pF max, respectively). If you do, you'll be able to "copy" the dial I used and get reasonable accuracy. Sorry, but I'm just not sure where I got it, nor of it's exact specifications. If it helps, it has a "TT" logo impressed on the plastic case, and the letters "TTWM", which may be a series number. It also has a "7" impressed on the front. I'm pretty sure it was the same one used on the NorCal BLT tuner kit, but I can't swear to it.

But the best thing to do is measure it, and it turns out measuring capacitance of a variable is even easier than measuring inductance, but you do need to do it accurately. In recent years, lots of handheld digital multimeters have had capacitance measuring capability on them. Alas, they usually will not accurately read capacitances less than 1000 pF. Frankly, I've found my gizmo Junkbox Capacitance Checker to be very accurate down to 10 pF or less, and can also account for stray capacitances. It's another Saturday project, but one you'll be glad you took on. Otherwise, you can visually determine the capacitance if -and only if - the rotor plates are semi-circular, and if you know the minimum and maximum capacitance. Often, the min/max is published by the manufacturer. If you make a dial with even divisions, then you can determine the capacitance at each setting.

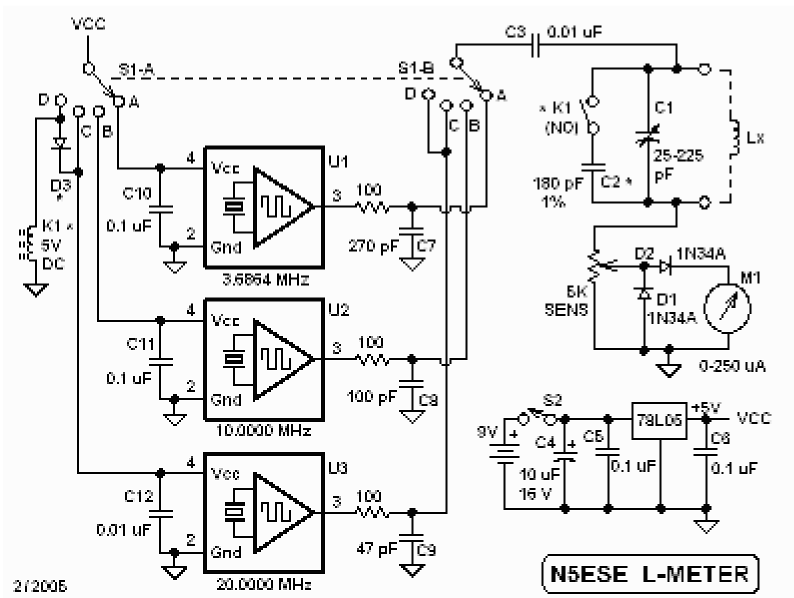
How'd You Do Yours, Smarty Pants?

I mounted my capacitor in the junkbox cabinet (minibox), and wired it up minimally with the clips I was going to use for attaching the unknown inductor. This way, I could include any stray circuit capacitances. If you have integral trimmers on your capacitor, set them to about mid-point. I then went to my PC, and built a scale marked in 10 degree increments from 0 through 180 degrees. You could just as easily do this by hand also, using pen and paper and protractor. I improvised a dial pointer using a sewing needle and a knob. I set the tuning capacitor at 0, then 10 degrees, then 20, etc, and measured the capacitance at each setting, keeping a log of same. Don't forget to subtract (or null) the stray capacitance of your capacitance measuring device, but don't subtract the stray capacitance of the L-Meter circuitry.

Once I had accurately measured the capacitance of my tuning circuit (sans unknown inductor), I interpolated between the 10 degree steps to get the capacitance at each 1 degree increment. At this point, I could have stopped, because if you know the capacitance at any given setting, you can use the formula to determine the unknown inductance. But I wanted to fancy it up a tad, plus make things easy on myself during future homebrewing projects. I wanted to construct a tuning dial that was calibrated directly in micro-henries. So I plugged the capacitance values into an electronic spreadsheet, and let it calculate the inductance values for me at each 1 degree increment, and for each of the three source frequencies. If you want to use the same spreadsheet (MS Excel v4), click -here-. Now, using a CAD drawing program (AutoSketch v2.1, in my case), I marked the dial in reasonable measuring increments, not in capacitance, but in micro-henries (corresponding to the value found in the formula based on the capacitance and frequency). What resulted was the dial you see in the pictures, available in MS Word (v6/97/2002) -here-, if you're using the same capacitor. To the degree you measure the tuning capacitor accurately, and account for stray capacitances, and construct the dial with care, you'll get an instrument that measures with amazing accuracy (say +/-5% or better).

On With Construction

Here's a schematic of our version:



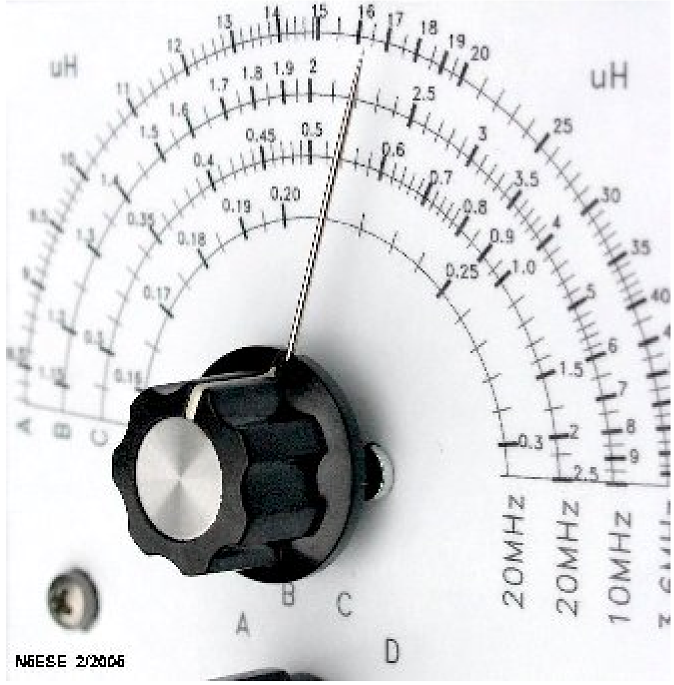
(click on the picture to see larger version)

Keeping with the KISS principle, we used whatever we had available for construction. You should do the same. Really! Parts are extremely non-critical.

A few years ago, we had purchased some mini-box type cases from TenTec (who manufactures enclosures, if you didn't know) while they were on sale. They sat on the shelf gathering dust for years, until I got this wild hair to build an L-Meter. The case is a two-part U-construction aluminum type, approximately 4 x 3 x 1.5 inches. If you want to duplicate my construction, I think you're out-of-luck, because this box was discontinued (which is probably why they were on sale HI HI). No matter, anything that size or bigger will do the trick, or build it on a hunk of cast-off plywood.

The dial pointer was built out of an available bakelite knob, into which I carefully drilled a 0.032" hole (using a carbide drill) laterally into the knob skirt. Then I "found" a sewing needle that would just fit into the hole, blunt end first. Between the Ballpoint RF Probes and this and other projects, the XYL's stash of sewing needles has gradually been dwindling... so far, she hasn't noticed...

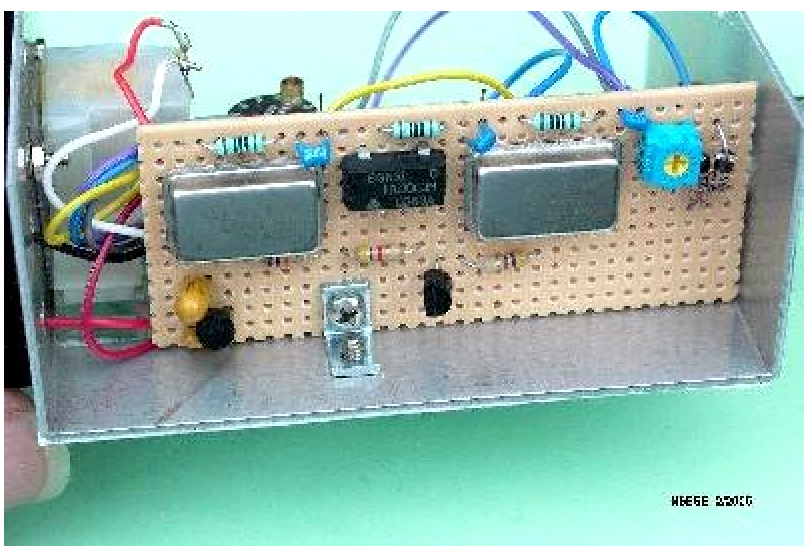
Here's a picture of the dial pointer and the dial (described earlier):

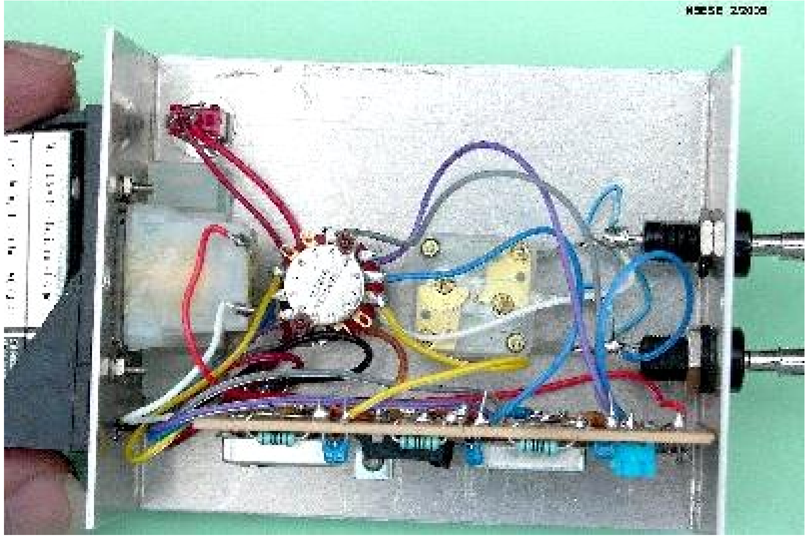


(click on the picture to see larger version)

The dial and front panel label was made on the PC, and printed onto "sticky-back" paper (mailing labels, full-sheet size, available at any office supply store), onto which a "sticky-back" clear laminate was applied. Of course, the front panel part will only apply to my enclosure, but you can download it in MS Word (v6/97/2002) format -here-, if you want to print and cut and paste from it.

Except for the front-panel mounted parts, components were mounted on perf board, then wired super-ugly style to the DP6T rotary switch, which I had picked up at a recent swapfest. If you wanted to skip the rotary switch, and are happy with just two ranges, you can use a DPDT toggle switch. Here's a gander inside:





(click on the picture to see larger version)

Keeping the wiring loose, not bundled, is ugly but it helps to reduce stray capacitance. Really, that's my story and I'm stickin' to it...

As I mentioned before, we used what we had, and we used clock modules that we had pulled out of old modems years ago. Instead of 5 MHz, we used 3.6864 MHz, because that's what we had, and the dial we constructed reflects that choice. Turns out, we still had a nice overlap between ranges, which is what we were trying to acheive.

The clock modules run on 5 volts, and I wanted to run off a 9 Volt battery, so we had to knock that down to size using a three-terminal regulator. The 78L05 is a cheap TO-92 package device, but it's quiescent (idle) current is about 5 mA, which means we needed an ON/OFF toggle switch to save the battery. If you substitute one of the micro-powered regulators (like the LP2950 or LP2985), you could dispense with the switch, and simply turn the rotary switch to an unused position to turn off the unit. By the way, the clock modules will eat up a 9 Volt battery in a few hours, so only turn on the unit while you are making measurements. No warm-up is required.

As you can see from the pictures, the 9 Volt battery was mounted outside the case, to facilitate easy change-out.

Two banana jacks were mounted on 0.75" spacing at the top of the box, and form the connector to the unknown inductance. We built clips for attaching the unknown inductance from alligator clips and banana plugs, removing the insulation from the banana plugs, and soldering the clips to the plugs. The alligator clips assembly, then, is easily removed, and another assembly can be fabricated for say, surface mount inductors. Here's a picture of that end of the box:

(click on the picture to see larger version)

Finished out, the front panel looks like this:

As you can see (above), the needle dial is readily and precisely readable. Protecting the dial's needle is an issue I haven't addressed yet, beyond putting it in a box. If you have any clever suggestions, please let me know.

Yeah, yeah - but does it work?

Oh yeah, it works. I haven't compared it to a lab instrument, and I have no precision inductors in my junkbox, but I took a sampling of 5% commercial inductors from my junkbox, and measured them using the L-Meter, and was pleased to find that all read within tolerance, from as low as 0.47 uH to as high as 47 uH. We were able to measure inductance over the full range for the three ranges we implemented, covering 0.3 - 65 uH, and we got good deep dips on everyone we tried. We also searched for false dips, and found none of any significance whatsoever.

In the schematic, you'll notice some components marked with an asterisk (*). These have not yet been implemented, and will form range "D". Here, we'll add a 180 pF 1% silver mica capacitor in parallel with the tuning capacitor, and only on range D (20 MHz). We could implement this with a SPST switch, but there's not a

lot of room left on the front panel. Thus, the proposed relay. We'll see how this develops, but hopefully, this will allow us measurements down to 0.15 uH. This should be suitable for RF circuit development into the lower VHF range (6 and 2 Meters).

We took the meter to "show and tell" at the local QRP Club meeting, along with a handful of inductors, and everyone had a blast finding the inductance and sorting them out. There's something intrinsically satisfying about "dipping" meters, that we rarely enjoy with modern Ham equipment..

73, and enjoy! monty N5ESE

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N5ESE's Version of the Arizona ScQRPion's Stinger Singer

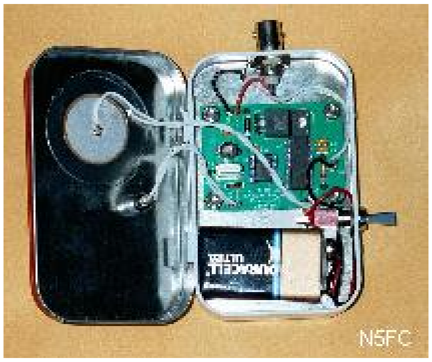
(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

I was excited when the Arizona ScQRPion QRP Club decided to release a PIC-based frequency counter kit called the **"Stinger Singer"**. At a mere $20, it represents one of the best test equipment bargains for the radio amateur.

The Stinger Singer measures HF frequencys (to 30+ MHz), and annunciates the frequency audibly, using morse code. Originally, the kit offered two speeds, the lowest of which was 18 wpm. Now, a second version is offered at speeds of 10/15 wom, siutable for the ham with novice CW skills.

The kit was intended to assemble in an Altoids box, and that's exactly what we did. We scrapped the RCA connector provided, and used a BNC instead. Also, we added a power switch so we don't run down our little 9V battery. Here's a picture of our assembly, viewed with the cover open:



(click on the picture to see a larger version)

Review

What a nifty counter this is! Keep in mind this counter is intended as a test instrument, not as a virtual display (like the Freq-Mite). As such, it won't allow a programmed offset from the actual frequency. But as a straight-ahead freq counter, it's superb! It did as well as my commercial counter, in about one-twentieth the space. It has several "display" options. One I found quite useful was mode "F". In this mode, using my Crystal Checker, I was able to grade fifty 16 MHz crystals in about half-an-hour. Neat!

I heartily recommend this kit, even for beginners!

73!
monty N5ESE

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N5ESE's Zero-Beat Tuning Aid

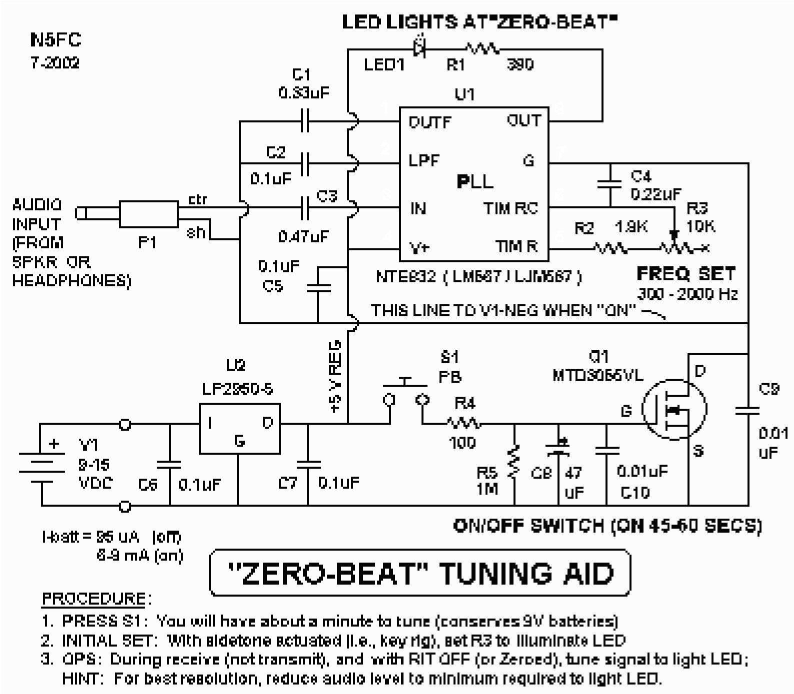
(click on any picture to see larger version)

NOTE: 'N5FC' is my former call.
This project was constructed while that call was valid, and you may observe references to it.

I never used to have problems hearing zero-beat when tuning my transceiver. But at some point, I turned into a geezer (*Hey! not an OLD geezer!*) and can't seem to find the right tone. You know the drill, typical on most transceivers. Preparing to answer a CQ on CW, and with the RIT off, you slowly tune the received signal until it reaches the magic tone that means "zero-beat". Usually, this is the same tone as your CW sidetone, 500-800 Hz, depending on your rig. You need a good ear for pitch.

Whether you're tone deaf, or just a geezer like myself, you might benefit with this handy little tuning aid. Connect it in parallel with your speaker or headphones. When you're ready to zero-beat the station calling CQ, press the pushbutton. This gives you about a minute to complete your tuning, at which time it shuts itself off, and conserves the 9 Volt battery. While it's on, tune through the signal slowly, stopping when the LED lights it's brightest. VOILA!, You're zero-beat! Backing down on the receiver's audio gain reduces the detection bandwidth, giving your zero-beat more accuracy, but I've found you can easily get within 100 Hz with normal volume levels.

See the circuit below:



(click on the picture to see larger version)

The circuit is a classic tone-detection application of the LM567 Tone Detector/PLL. Audio from the speaker or headphone line is applied to the LM567's input pin through coupling capacitor C3. Capacitors C1 and C2 set the PLL's bandwidth and loop filter characteristics. These values are non-critical and can be varied +/- 50% with no noticeable difference in performance. R3, in series with R2 and together with C4, sets the desired tone (i.e., the PLL reference), and should be set to the transceiver sidetone. Just key (into a dummy load), allowing sidetone audio to be applied to the LM567 input, and adjust R3 to provide the brightest illumination of LED1. With the resistor and pot values shown, you can set the detector to any tone between 300 and 2000 Hz.

S1, R5, C8 and Q1 form a time-delayed electronic switch for turning the circuit on and off, to conserve the 9 Volt battery. As shown, you can expect 6 months to a year of operation from an alkaline battery. Here's how it works: U2 is a micro-power 5 Volt regulator. It draws only 100uA when the circuit is in its "off" or "rest" state. In this state, no ground is applied to the LM567 and supporting circuitry. When S1 is pushed momentarily by the operator, C8, a 47 uF capacitor, is quickly charged up, and Q1's gate is simultaneously brought above it's "ON" threshold of roughly 2.5 Volts. When this happens, Q1 turns "on", providing a low resistance path from its Drain to its Source, and so a ground for the LM567 and supporting circuitry now exists. As the pushbutton is released, C8 begins to discharge through 1 M resistor R5, but it takes about 45-60 seconds before Q1's Gate voltage falls below the "ON" threshold, which will once again turn the circuit off. This gives the operator (and the LM567 PLL) plenty of time to do the tuning job, but allows the 9 Volt battery to be conserved, because it only supplies significant current when required.

If you don't want the added complexity of the automatic power switch, replace it entirely with a conventional SPST switch. Keep the regulator though, so that the PLL circuit's reference frequency will not be affected by voltage variations as the 9V battery dies. If you don't use the automatic power circuitry, an 78L05 will work for the regulator.

I constructed mine on a small PC board, using a hobby knife and "cut and peel" techniques to "etch" the PC pattern.

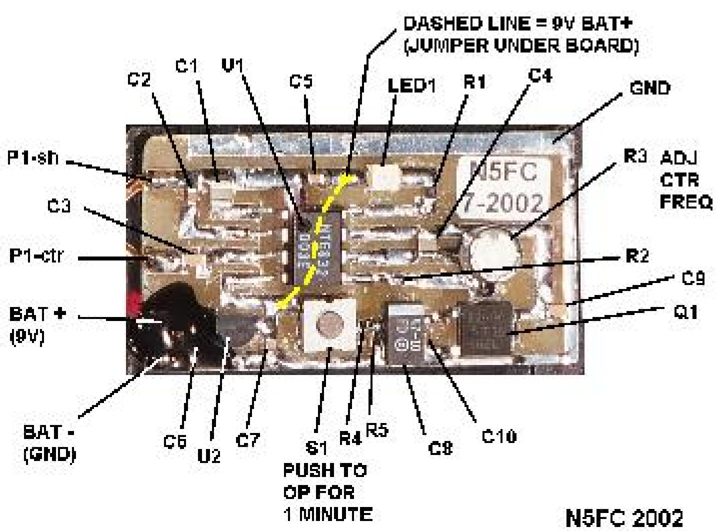
CAUTION! *ALWAYS ALWAYS ALWAYS* wear eye protection when using this technique.

I sized the board to just fit inside the border of a plastic 9-Volt battery holder. All parts were surface mounted, even the "thru-hole" parts (like attached wires, pot, regulator, and the DIP IC). Where possible, surface mount

caps and resistors were used. When assembled, the board was mounted on the back of the battery holder, providing an extremely light and compact assembly. Here's what it looks like:

(click on the picture to see larger version)

And here's the layout, annotated:



(click on the picture to see larger version)

You can find a photo of the raw PCB -here-

The circuit will work as well with other construction techniques and regular thru-hole components, so feel free to use your own favorite construction techniques and whatever parts you have in your junk box.

73,
monty N5ESE

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N5ESE builds the
M-Cubed Electronix Semiconductor Analyzer

(click on any picture to see larger version)

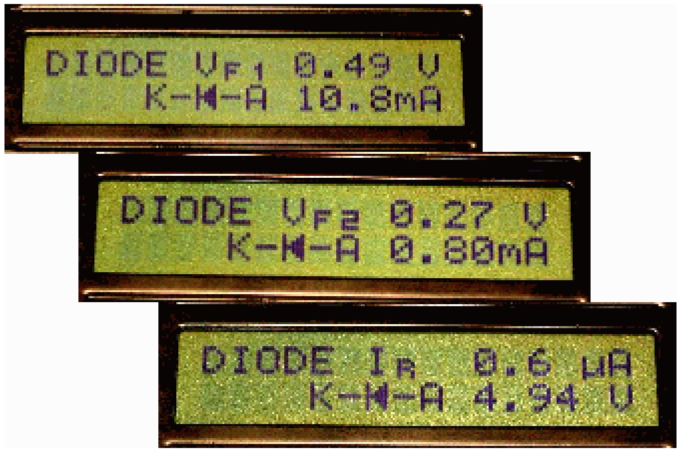
Here's a little gem of a kit I just heard about, and when I did, I wondered how I managed to miss it. This M3 (or M-Cubed) Electronix kit is a first-class semiconductror analyzer (SA) for under $50, which will detect and analyze practical DC parameters for diodes, bipolar, JFET, and MOSFET transistors, and even thyristors and unijunction transistors. Wow!

Do I need to be an engineer to find this useful?

Heck no! ... but if you're an engineer, you will appreciate some of the advanced features.

The SA has a 2-line LCD display, and three "clippy" leads for connecting to your "device under test" (DUT). Aside from a power switch to turn it off, there are no buttons to push. Operation is completely "automagic"

Let's say you have one of those glass diodes, and the markings are so bad that you're not sure which is the banded end. You could grab your trusty VOM, put it in "Diode" mode, and figure it out that way, and hope by the time you get it to the board, you haven't swapped the leads... was that the red or the black lead you had on that end? But clip it on the M3 SA's two outermost leads any old way you want, and the SA's display will show you visually which lead is the cathode (K) and which is the Anode (A), like in the top panel below:



Here, we see that the DUT's cathode is the lead connected to the leftmost clippy, and the anode to the rightmost clippy. Had we connected it the other way, it would have been shown the other way. The diode symbol even helps the beginner remember which is the cathode and the anode, in your schematic. Cool, heh? Theres so much information, in fact, they need to have three LCD panels in succession, at about 5-second intervals, to display it all.

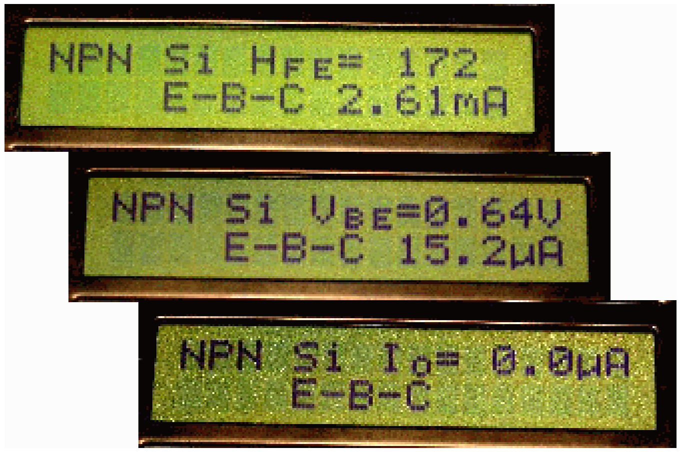
Ever need to match diodes for use in a balanced mixer? The M3 SA can help you do it easily. It will show the forward voltage drops at two different currents, and the leakage current too. In the picture above, the DUT (a 1N34A germanium signal diode, by the way), we see that the Forward Voltage Drop is 0.49V with 10.8 mA applied (panel 1), and 0.27 V with 0.8 mA applied (panel 2), and the Reverse Leakage Current is 0.6uA with 4.94 V applied. Hey, we just discovered a leaky diode!

The M3 SA has enough built-in-capability to handle voltages up to 9 Volts, and test currents up to 12 mA, and enough smarts to interpret the results into useful paramenters. One of the pleasant surprises I discovered was it's capability to screen LEDs. If you've ever homebrewed with LEDs, you know that one lead is just a smidgeon longer, and that lead is the - oops - which was it? No matter, the M3 SA will find out for us:

Let's look at the results above. From the first panel, we see the Cathode (K) and Anode (A) marked, Cathode on the right clippy, anode on the left. But we also see that this LED has a forward Voltage drop of 2.00V with 7.2mA, and 1.80V with 0.54 mA, and little or no leakage current. Knowing the voltage drop is essential to selecting the correct series limiting resistor value to place in the circuit. But wait! There's more, and it's free! While the M3 SA is doing it's diode tests on the LED, it's pulsing said currents through it, and the LED is LIGHTING! So by watching the LED as the SA cycles through the various panels, you can see how bright it's going to be at 7.2 mA and at 0.54 mA, and you can judge what would be a reasonable current for the brightness you want from the LED. This is sooOooo cooOool !

Well, so we know it does a great job on diodes. Lets see what it does with one of those three-legged critters. We grabbed a 2N2222 out of an envelope with about a hundred in it, and hooked up the three clippies, one to each

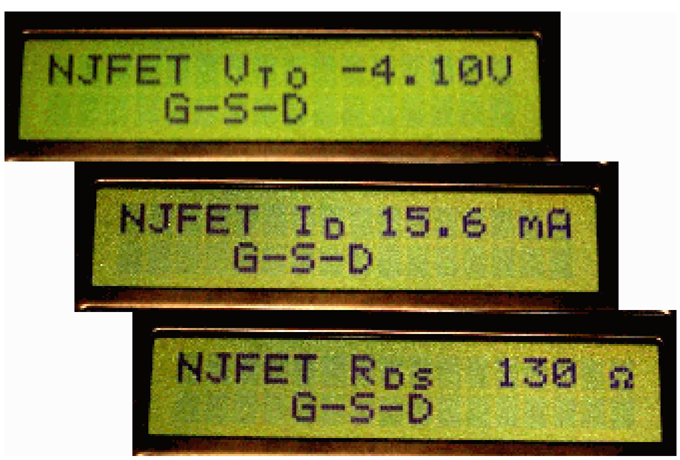
lead of the transistor. It doesn't matter which lead goes to which clippy. The M3 SA is going to figure out which is which and tell us. Here's what we got:



The results show up about a half second after we clipped on the third lead. From the first panel, we see that the M3 SA has identified this as a NPN, probably silicon (Si), and the Hfe measures 172 at a collector current of 2.61 mA. Hfe is the DC current gain, and one of the key parameters you need to know for correctly biasing a transistor. It is especially critical to know when designing cascaded DC-coupled stages. We see here that this transistor is typical for a 2N2222, which is specified to have Hfe in the range 100-200. Chances are this transistor is good in other ways, too. In panel 2, the M3 SA has taken the base current (15.2 uA) used to produce the collector current in panel 1, and has measured the actual Vbe (base-to-emitter voltage, kinda like a diode drop), a parameter which is also needed for bias circuit calculations. Finally, in panel 3, we see the emitter-collector leakage current (with no bias applied). In a good, small signal transistor like the 2N2222, we'd expect to see something less than 1 uA (and we see zero).

The M3 SA can detect shorts and opens in transistors, which are common failure modes when they overheat or otherwise operate outside their safe operating curve. It can also detect a shunt resistor in the base-to-emitter circuit (not sure I've ever seen that in 40 years of electronics) and a protected diode embedded in the collector-emitter, and will so indicate on the display.

Here's what happened when we hooked up a MPF102 transistor to the M3SA:



The SA correctly detected that this is an N-Channel JFET, and correctly identified the leads Gate (G) - Source (S) - Drain (D) from the left clippy to the right clippy. Incidentally, it's practically impossible to differentiate between the Source and the Drain in a junction FET, using an ohmmeter, and the guys a M-Cubed have figured out some slick way to do it reliably. That in itself makes the SA worth the small expense. I can't tell you how many times I've smoked a FET by having the leads wrong. Even all MPF102's are not pinned out the same way, which is extremely annoying to discover after you've been troubleshooting a homebrew circuit unsuccessfully all day long.

In panel 1, the SA also told us that the pinch-off voltage (Vto) is -4.10 V and panel 2 says that the Drain Current with 0 Volts applied is 15.6 mA. By the way, the guys at M-Cubed are showing off again, because they're doing some predictive calculations to come up with that drain current in a tester that can only provide 12 mA. But it's a very useful parameter to have when designing with JFETs. Panel 3 tells us that the Rds-ON (saturated Drain-to-Source On Resistance) is 130 ohms.

The M3 SA can also detect and measure MOSFETs. There are small signal and power mosfets, and the SA can only measure enhancement-mode types. Fortunately, most of what is on the market today are. Lets look at two:

These are both power MOSFETs. MOSFETs generate only one panel with the SA, but one of the most critical pieces of information is on that panel, the Gate Threshold Voltage, Vto. In the top image, the SA correctly identified the leads on our IRF510, and labled it an NMOS device. It then measure the gate threshold volatge as 3.33 Volts, which is pretty typical of this class of transistor. We wouldn't be able to use this transistor in a 5 Volt TTL logic circuit, however, because it wouldn't reliably turn on.

We put another transistor on, the MTD3055EL, and discovered it would indeed be suitable for TTL logic circuitry. As seen in the second image above, its gate threshold voltage is 1.56.

There is a critical parameter missing on the MOSFET panels, Rds-ON. I found it curious that the same parameter would be shown for JFETs, but not for MOSFETs, especially considering it is a much more critical parameter in power MOSFET devices. I asked M-Cubed about it and was told that it was left out because they had no more program space in the PIC microcontroller they were using to do that calculation and display it. Hmmm. Oh, well, one minor shortcoming amongst a mountain of features.

We didn't examine some of the capabilities of the M3 SA, because I didn't have some of these devices in my junk box: SCRs, Triacs, and Unijunction Transistors. Unijunctions? I haven't seen one in the flesh since about 1975, and even then they were an oddity. The SA is also capable of measuring current transfer ratio on an optocoupler, with the addition of an option module. You'll have to ask M-Cubed about that little feature.

Building the M3 SA

For $6, you can get a plastic utility box with all the holes (including the LCD rectangular window) already nicely milled out for you. In fact, I got it. Good Price, and should really simplify construction.

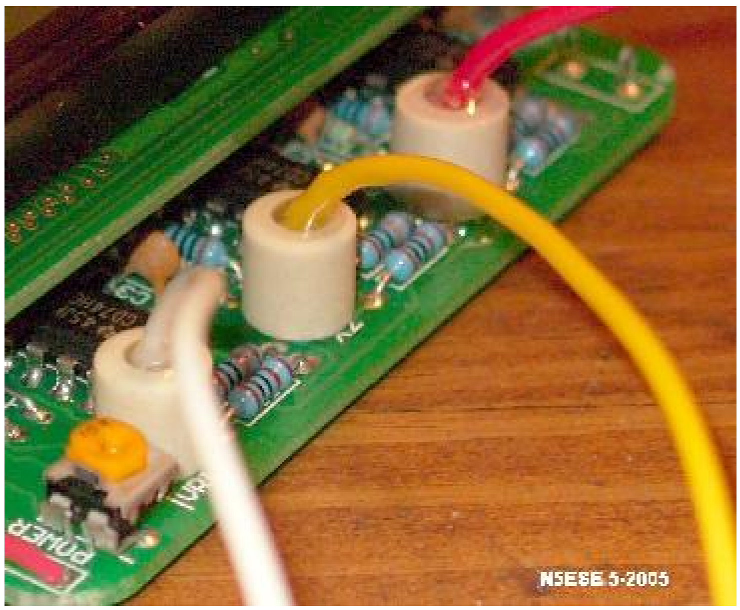
But any of you that follow my homebrewing pursuits know me better than that. If it'll fit in an Altoids tin, that's where it's gonna go. Well, this one wouldn't, but it would fit in a Whitman's Sampler tin - HI HI - which is about a tenth of an inch deeper and half an inch wider, front-to-back. I'd have to do some drilling and filing to fit it in there, but that won't stop me from indulging my addiction for candy tins (and candy).

I sat down and played with the main PC board and display for a while to see what had to be done to fit it in the can. M-Cubed pretty much expected the LCD to mount to the front panel at 4 points using hardware provided. I didn't want to cut a rectangular hole in the super-thin sheet metal of the sampler tin, so I opted to mount the LCD display to the main pc board. Trouble is, there were no holes on the main pcb for doing that. So I made three: top-left, top-right, and bottom right, to match the display mounting holes. In the process, I drilled through 2

traces, which I cut back from the mounting hole, and repaired with a short piece of kynar-covered wire-wrap wire.

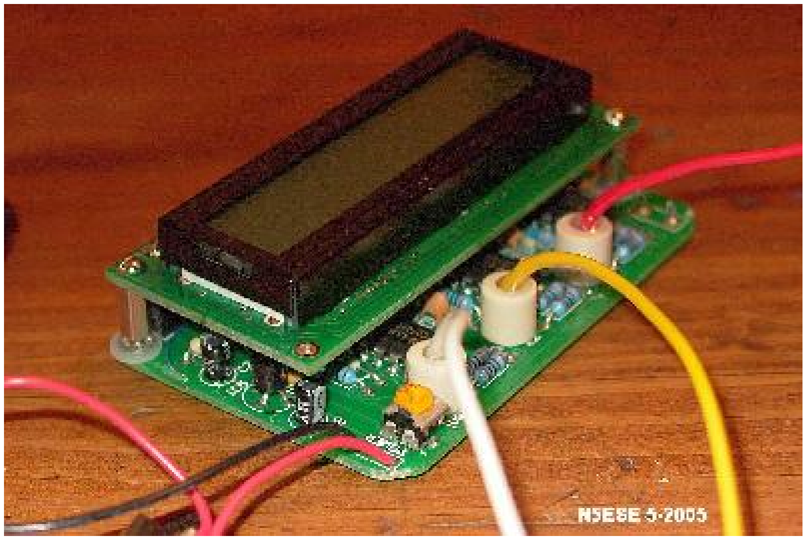
I also rounded the bottom-left and bottom-right corners of the main pc board. That allowed the main pc board to be moved closer to the front side of the sampler tin, giving me just enough room behind it to install the power switch and the 9-Volt battery. I substituted a micro-toggle switch for the toggle switch provided in the kit, to assure there was room for the battery and its wiring.

One weakness that was mentioned by the supplier was that the leads needed some sort of strain relief. The test leads are made from common hook-up wire, with 7-stranded copper wire and PVC insulation, so it wouldn't take long before metal fatigue set it and one of the leads broke at the solder joint. M-Cubed suggested hot glue, but after a short but furious rabble through the garage, I gave up on that idea. Instead, I got three short ceramic standoffs from the junk box, and super-glued them over the lead's holes in the pc board. Then I soldered the leads in place, so that they stuck straight out of the ceramic spacer. I then mixed up some 5-minute clear epoxy (which I find is a great electrical potting compound), and filled the spacers with the epoxy, forming what I think is a very durable lead arrangement. See the picture below:



(click on the picture above to see larger version)

Below is a picture of the overall assembly, before installing it into the Whitman's Sampler tin. The LCD display is held rigidly to the main pc board using 3 threaded spacers and 2-56 hardware, with a nylon washer to protect the main board where the spacer mates to it.



(click on the picture above to see larger version)

Finally, here are two pictures showing it's installation into the tin:

(click on the picture above to see larger version)

The pc board mounts directly to the bottom of the tin, using some 3-M double-sided foam tape. I made sure to clip all the leads on the bottom of the board very close with my flush-cutting dikes.

See, it really does fit! Even the leads fit inside the tin, protected from whatever corner of the bench I threw it in last. When I want to measure a transistor or diode, I just flip the top open, flip the power switchto ON, pull the leads out, and have at it!

(click on the picture above to see larger version)

Conclusions

This kit is a real value, not only for it's reasonable price, but for its utility on the bench too. This is really going to go a long way toward taking those random uncertainties out of homebrewing and kit-building.

73,
monty N5ESE

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